FORESTS CATCHMENT AREAS AND WATER SUPPLIES

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FOREWORD

This enquiry was undertaken originally to obtain some information on the amount of High Forest still standing on the Catchment Areas (or Drainage Basins) of certain rivers in which I was interested. The meagre information available which proved to be the same for other selected rivers led to the attempt being made to endeavour to find out the world position outside Western Europe, Scandanavia, etc.

Part II will show the extent of my indebtedness to a host of Forest Officers, known and unknown to me except by name—to all of whom I offer my sincere thanks.

In any event we know to some extent where we all are.

On a tout dit sur l'utilité de la forêt, beinfaisante à la terre et à l'humanité, gardienne de l'eau, réservoir inépuisable de forces, par qui s'établit l'équilibre du climat et se reconstitue le sol nourricier : c'est elle, les savants contemporains nous l'apprennent, qui restaure l'energie utile dans un monde qui va sans cesse s'usant et se degradant. L'existence de l'homme est si intimement liée à celle de la forêt que la disparition menaçante des forêts, signifierait, pour nos sociétés, l'irrémédiable déchéance, et, pour notre globe luimême, la mort lente et sûre. Et cependent c'est un fait indéniable et douleureux ; les réserves de notre globe s'épuisent ; nos vieilles futaies tombent sous la cognée du bûcheron, sans qu'on laisse au capital-bois le temps de se reconstituer.

Bernard Brunhes, Director de l'Observatoire du Puy-de-Dôme.

QUESTIONNAIRE

The following questionnaire was sent to the Head of the Forest Services throughout the world, with the exception of Western Europe :—

1. The names of the chief rivers in......................................and the length in miles from the source to mouth where they flow into the sea.
2. The names of the chief tributaries of these rivers and the length of each tributary from source to where it joins the main river.
3. The amount of forest still standing on the upper reaches in the mountains and hills of the main rivers from their source down.
4. The amount of forest still standing on the main tributaries of each of the main rivers.

5. What I mean by the amount of forest is really the area of the Catchment Areas which has been cut down or ruined by shifting cultivation and excessive grazing and what area still remains forest.

Of course, I only want the above information in its roughest form ; in other words, the information which any Forest Officer acquainted with the region would be able to give.

The Plan here shown taken from "Geological Survey Circular 44, 'Large Rivers of the United States' " prepared by the Water Resources Division of the Department of the Interior, May 1949, of the Mississippi and its tributaries and the tributaries of the latter, indicates the type of information required to answer the above questionnaire. We require to know what forest or other vegetable covering shown in shades of green exists at the head waters or catchment areas of the main river and its tributaries and those of the latter and have the plans or maps prepared. With this information before him it should enable the Forestry Advisor in any country to judge whether the water supplies of the country are being adequately preserved or otherwise and to advise on steps to be taken.

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FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

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COUNTRIES DEALT WITH

PART I

What is the connection between the Forest and the amount of water required for the successful growth of agricultural crops ? To which may be added in the modern world the provision of the necessary water supplies for the big cities and towns existing in various parts of the globe ; including hydro-electricity schemes for producing power for lighting and industry.

There is scarcely any portion of the inhabited globe to-day where the water question in one form or another does not present grave problems to man. And there is scarcely any walk of life or occupation of man which may not be affected directly or indirectly by water—either, less frequently, by its superabundance or in the far greater majority of cases by its deficiency, ending in a total failure of Nature's supplies.

Perhaps it is the Forester of some experience combined with a certain amount of travel and practical study in the forests of varying types growing under different climatic and elevation conditions, who is in the best position to collate and formulate some opinions on the question of Forest and Water Supplies. Approaching the question not from the old much-discussed viewpoint as to what effect forests have in attracting or otherwise rainfall ; but from the basis of the effect of the forest directly on the maintenance of water supplies.

It may be submitted that in this question and its possible solution lies the fate of the human race in the future. For there appears to be an increasing unanimity amongst those who have given some study to this vital question that degradation of the forests, misuse of the soils, increasing aridity and decrease in the water supplies available to man is making itself evident in various parts of the world. While there is little recognition of the appalling aftermath being left behind them by the chief offenders against Nature's laws—the forest lumberer, the commercial stock grazier of all types ; and that wasteful form of agriculture practised by the far more ignorant class of man represented by the shifting cultivators ; also responsible, with ever increasing flocks, for much excessive grazing ; both combined with the annual firing of the country-side.

I have examined this matter in several contries and have come to formulate certain conclusions. It is interesting and important to note the views expressed by so well-known an investigator as Raphael Zon in a paper entitled "Forests in Relation to Soil and Water" published in Proceedings of the American Philosophical Society (1945). The author says :—

> "The entire philosophy of the role of the forest is based on the ability of the forest to prolong the water cycle from its inception as falling precipitation to its final disposal as runoff into streams and oceans. The longer the water is retained on the land, the greater is its usefulness in nurturing crops and trees, in maintaining a regular supply of water in streams, and in preventing the soil from washing. Simple as this relationship is, yet so many are the factors which play related parts in this influence, so great is the difficulty of observing them with precision, and so wide the range of economic interests affected, that considerable divergence of opinion still exists on the subject.
>
> "The chief influence of a forest upon the moisture conditions of a locality lies in the manner in which it disposes of the precipitation it does receive. By breaking the violence of rain, retarding the melting snow, increasing the absorptive capacity of the soil, preventing erosion, and checking surface runoff, forests increase underground seepage in general. In this way, precipitation, which without the forest cover is

rapidly disposed of by surface runoff, is retained in the soil and gradually utilized for the growth of trees and crops and for maintaining a steady flow of water in streams.

"This retentive power of the forest is brought about in several ways. The forest cover affects the temperature, the relative humidity, the wind velocity, and through these influences diminishes the loss of water through evaporation from the soil.

"Furthermore, the crowns of the trees may intercept as much as 15 to 30 per cent of the total precipitation. This water is evaporated back into the air to come down later somewhere else in the form of precipitation. The transpiration of water by the leaves, while it may decrease the total amount of water available for stream-flow, enriches with moisture the surrounding air and thus prolongs the water cycle on the land.

"Forest soils have great water-holding capacity. The humus in the forest soils holds water equal to twice its weight whereas sand and clay soils hold only one-fourth to one-half their weights of water respectively. What, however, is even more important is that the leaf-litter in the forests keeps open the channels in the soil through which the water percolates into the ground. This storage capacity of the soil under forests depends a great deal, of course, on the character and depth of the soil. A shallow soil underlain near its surface with impermeable rock does not provide for much water storage, but if the soil is deep the ground forms a vast natural underground reservoir. As well-known hydraulic engineer, H. J. Morgan, remarked, 'Dams are good, but if we could raise the underground water-table of the Tenessee valley only six inches, that would mean twenty-six million acre-feet of water—four times as much as the Norris Reservoir will hold—Nature would do the storing'. The best aid to Nature in storing this water is well protected forests on the watershed.

"In the past, in discussing the calamitous effects of forest denudation, the Old World was drawn upon for examples—the denudation and over-grazing in the Alps and Pyrenees, with resulting disastrous torrents and their destruction of life and property; the deforestation in China and in the Near East and its terrible consequences. Fixation and reforestation of the shifting sand dunes in the Landes region of southern France and the extinction of the Alpine torrents by combined engineering works, sodding, and reforestation were cited as examples of the value of forests in remedying and preventing such disasters.

"To-day, unfortunately, we do not need to go to the Old World for such lessons. While the effects of the disappearance of the forests of this country have not yet reached the calamitous proportions that they have in some countries of the Old World, there is enough evidence to serve as a warning of what may come if the natural vegetative cover on the land is destroyed. Forest denudation, followed by gross misuse of agricultural land, has already resulted in the loss of millions of tons of soil material annually washed by the Mississippi into the Gulf of Mexico. The productiveness of some 57 million once-fertile acres has been essentially destroyed; that of another 225 million acres has been seriously impaired; and the fertility of 775,678,000 acres more is threatened. These striking facts have recently attracted the attention of the people".

Since water is the most important agency in the growth and maintenance of a vegetation on the land the study of the available supplies and their failing amounts becomes of first importance and a fascinating but difficult study. Inferences as to storage, runoff, precipitations, evaporation, water-tables and water-levels are easy to make—but where is the proof?

More especially perhaps, will this attitude be found in countries where the main reliance is made upon wells and tanks (reservoirs). Rivers and streams formerly existing having disappeared and lakes dried up.

I think, however, if we regard this matter from the broader base of the world as a whole, it is to the rivers we must go to obtain the information required, to the catchment areas of the main rivers and their chief tributaries.

It is here we shall at least find answers to our main problems, the *causes* of the decline of the water once available in amounts to satisfy all requirements of man and his animals and crops ; and with the water the wholesale disappearance of valuable agricultural top-soils.

What is the present condition of affairs away up in the great Basins of some of the largest and more important rivers of the world ? Though mere size is not a sole factor of the importance of a river.

It may be suggested that if we are to understand this water supply question from the point of view of modern man and his growing populations and, therefore, increased demands for food—the latter the product of the soil plus water—the study should commence with the sources of the rivers and their tributaries to definitely find out what proportion of forest clothes their catchment areas, its type and how managed. For it is becoming more and more apparent that only with this knowledge, and the knowledge now requires to be exact, not based on hearsay and rough estimates ; only in this way, I say, can an attempt be made before it is too late, to protect or at least stop the final devastation of the chief sources and areas of the world's diminishing water supplies.

It is a work for the Forester, for only he possesses the knowledge and required training to assimilate that knowledge. But how much do we know of this important factor in the lives of Man ! Even we Foresters !—Is there a country of any size in the world who can give us definite answers on the forests clothing the catchment areas of their chief rivers and their tributaries ? Some countries in Western Europe perhaps. But Western Europe with her efficient Forest Services is not considered in this paper. And Russia, for Russian scientists have for long made a study of erosion, and so forth.

But in this paper it is not erosion that forms my chief purpose.

Are the water supplies available to man dropping in amount and if so why ?

I submit that the answer is to be found to some degree by a study of the rivers of the world so far as information is at present available—for it is lamentably deficient even in countries which have had a forest service established for decades of years. But in the majority of cases the want of available evidence can, for a variety of reasons, in no way be attributed to laxity on the part of the forest services.

A proportion of the larger rivers of the world have their source of origin up in the glaciers in high mountains probably in the regions of permanent snow. They thus rise at elevations considerably above the upper limit of forest growth. Above this limit will be the Alpine valleys containing grass, wild flowers in the summer time, a period perhaps restricted to four months. The young river when entering the upper border of the forest may be joined by a spring or two or a small streamlet. As it continues on its way downwards the forests become more regular and denser (if untouched by man) and tributaries will now begin to join it (coming out of deep narrow valleys separating the forest-covered tier on tier of ridges dropping to the lower levels) increasing in size and volume of water power as the elevation becomes lower and the forest changes its character and takes on the characteristics of low level forest containing more hardwoods. On the lower levels before entering the plains

country cultivation may have been met with—a sparse and rude cultivation for man is at present in scanty numbers and the exposure is severe.

The main river flows out into the plain widening its bed and with its current becoming slacker. The water is clear, perhaps light green or blue. As it flows onwards on its long course of 1,000 or 3,000 or more miles before it reaches the sea, the bulk of its water is increased by other tributaries joining it, themselves perhaps rivers of considerable size. The earlier ones originate in the mountains from which our main river comes—but lower down its course, greater tributaries join it which rise in mountains or hill areas which have no bearing upon or connection with the area in which the main river was born. Their waters are equally limpid and clear—little interference has taken place with the forests on their catchment areas.

Year in and year out, when untouched by acts of man, there was little variation in the flow of this main river and its tributaries. There will be little rise and fall in the volume of water—a slight drop in the summer time but nothing to cause any inconvenience to man and the animals dependent upon the river for their water supplies. In other words the rivers maintain their even flow and volume of water and have done so as far as studies and any existing historical references are available, for centuries perhaps thousands of centuries.

There is no doubt that historically it can be proved in the case of some of the great rivers of the world that they were in this position as late as a couple or so of centuries ago. In the case of others we require to look back for several thousands of years to find their waters of sufficient abundance to maintain man and his agriculture and his flocks. All have long since vanished—vanished with the trees and other vegetation they supported under the ignorant treatment of man ; leaving behind them great wide, dry, stony, rocky or sandy beds or deep cut water courses which may carry a brief flow from some rare cloud burst. For example the great rocky beds of rivers formerly flowing from the Atlas Mountains in the north of the West Sahara Desert as represented by the Sahara Wadi.

In the early times this ignorant utilization of the forest usually accompanied by fire, was made chiefly to grow the small areas of arable crops and to support the domestic flocks. Long periods of time elapsed before any visiable or practical influence began to make its appearance in the forest areas and larger grass lands. It was increasing populations and settlement into permanent centralized communities which resulted in larger demands being made upon the forest, sweeping the latter away in ever increasing amounts from the more accessible plains and foothills ; and then penetrating into the forest-clad hills as tools, equipment and extraction facilities increased in numbers and power for rapid exploitation.

This was when the first real interference with the water supplies in the big rivers and their chief tributaries began to show the inevitable results, variations in the volume of water at different periods of the year, the drop in level more or less coinciding with the hot season. The variable nature of the rainfall during the rainy season accompanied by serious floods. These variations, also the increasing aridity, commencing to make alarming progress in parts of the globe. What the appearance of the lumberman in the New World and in Australia, coupled with sheep pasturing, was able to produce in under a century, took thousands of years, of centuries, to produce in early times.

But the results so far as a study of them becomes increasingly possible, are the same—impoverished soils, decreasing water supplies, increasing aridity, leading to the man-made deserts.

It seems, therefore, that a close study requires to be made of the large rivers of the globe and their tributaries to ascertain the present day conditions of their waters and catchment areas and what amount of reliance can be placed upon them for the production of the water (and power from that water) which modern man requires for survival.

"Erosion" is probably one of the words most often on man's lips when speaking of interferences occurring, as he thinks, from Nature's uncontrolled impulses leading to cloud bursts, floods, avalanches or long periods of drought curtailing or reducing to nothing the water supplies. He has ignored in the past, and in many parts of the world up to the present day, the chief factor, his entire neglect of Nature's laws.

Once Nature's balance is seriously upset in the matter of water, the Rainfall becomes inconsistent and unstable, periods of drought set in, at first followed by periods of normal rain. But as soil conditions deteriorate intermittency of the rainfall becomes greater and no man can foretell what rain be may expect and even at what periods it may fall. Why ?

The area of the surface of the globe is 196,940,000 square British statute miles ; and its age according to the latest calculation based upon the study of radioactive minerals by Professor Arthur Holmes is estimated at 3,350 million years. The total land surface of the earth amounts to 55,143,200 square miles ; and the total ocean surface is 141,796,800 square British statute miles.

Of the land surface of the earth nearly 10 thousand million acres are classified as forest soil, or about twice the area under cultivation. Of this forest soil about 1,250 million acres are now denuded and useless, some of it comprising the great deserts, parts of which were formerly inhabited by man, the more recent dust bowls in United States and Canada, and the drift areas in Australia ; and the marginal lands to existing deserts and destroyed areas, themselves almost ruined and practically unproductive. Some 5,000 million acres consists of as yet untouched forest. Parts of this latter are already threatened by the lumberer.

Therefore, out of the total forest area either ruined or threatened with lumbering methods which have little regard to maintain the existence of the forest, there are only 750 million acres under some form of systematic management.

The other 2,250 million acres consisting of the bulk of all the forests of the world in use are lumbered and cut without ckeck or regard to their future permanence.

Forest Management in other words is still fairly limited, since it extends at best to one-fourth of all forests in use and to less than 10 per cent of the world's forest soils.

On the subject of deforestation it is now being increasingly recognized that in large portions of the world continuous mismanagement, fire and unrestricted grazing have led to complete destruction of the original forest cover. Vast denuded areas, deprived of the protective forest have become wind-swept deserts, barren mountain slopes and eroded valleys where agriculture is almost impossible, and living standards have remained at starvation levels for hundreds of millions.

What does this state of affairs mean and how is it to be tackled ?

Protection against erosion and the maintenance of a permanent water supply are the requisites of agriculture.

How is man to recover from some of the past grave and often ignorant mistakes made and stop further degradation and loss of soils ?

The answer naturally varies with the very varying localities existing on the surface of the earth. But until we know the actual position and condition of the catchment areas or drainage basins of the rivers we have no certainty.

It is to the rivers, and in dealing with the globe as a whole, the great rivers, to which we must go to obtain some of our answers and with the answers some idea of the amount of arrestation and repair work which the Forester will have to undertake if the world is to have

in the future sufficient areas of arable and grazing lands to provide its populations with their essential food requirements.

Some examination of these rivers and their chief tributaries and the conditions of their catchment areas is essential if the above efforts are to be given effect to. The attitude of the responsible authorities in the past too often influenced by vested interests coupled with a total ignorance of the working of Nature's laws must be radically changed if the world's increasing populations are to be saved from starvation.

Before this enquiry is undertaken it will be of interest to look at the elevation of the land belts in different parts of the world ; for to some extent elevations of the catchment areas of rivers have often been directly connected with their accessibility and, therefore, the destructive actions of man in clearing or want only and ignorantly destroying their forest cover.

The following tables show heights in feet from 0–600–24,000 and over of land in the chief regions of the world including the island regions :—

(The information in regard to land areas is taken from the Scottish Geographical Magazine Vol. IV, No. 1, January 1888 by John Murray of the Challenger Expedition).

TABLE 1

Superficial Area of Land at Various Elevations in square miles

Altitude in Feet	Europe	Asia	Africa	North America	South America	Summary of Land Area
Between						
0–600	1,975,550	3,817,200	1,393,750	2,462,300	2,725,550	13,746,950
600–1,500	991,800	2,603,700	3,859,850	2,450,550	1,842,850	14,284,400
1,500–3,000	362,000	3,551,950	3,066,200	1,015,900	1,151,000	9,882,350
3,000–6,000	205,150	3,558,200	2,415,800	1,014,750	483,700	8,720,250
6,000–12,000	62,800	1,635,300	317,550	642,700	346,950	3,107,750
12,000–18,000	6,950	826,850	21,700	31,800	280,350	1,172,800
Over 18,000	800	135,500	1,600	1,150	31,000	170,850
Over 24,000	..	7,800	..	..	..	7,800
					Total	51,093,150

The summary in the seventh column is for the total land area of the earth's surface.

Columns 2 to 6 do not include the island masses and are merely the Continents.

The Mean Height of the surface of the earth above sea-level is only 2,300 feet.

From these tables the following percentages for the area of land in the different zones of height are as follows :—

Below sea-level	..	.. 0·618%
Between 0–600	..	.. 26·741
600–1,500	..	.. 27·784
1,500–3,000	..	.. 19·222
3,000–6,000	..	.. 16·962
6,000–12,000	..	.. 6·045
12,000–18,000	..	.. 2·281
18,000–24,000	..	.. 0·332
Over 24,000	..	.. 0·015
		100·000

TABLE 2.—*Height of Land*

Island Regions

Height in Feet	Australia	East Indies	West Indies	Mada-gascar	New Zealand	Japan	Formosa	Tasmania	Saghalien Island
0–600	896,300	305,850	46,450	73,600	15,550	11,600	1,950	11,600	1,950
600–1,500	1,935,700	185,650	42,600	27,100	34,850	73,550	11,600	13,550	21,300
1,500–3,000	123,900	282,450	13,600	42,600	34,900	50,300	3,900	3,900	9,750
3,000–6,000	46,500	255,550	1,150	60,000	18,600	4,300	1,950	1,950	9,600
6,000–12,000	11,650	59,300	800	17,400	4,700	1,150	1,950	..	..
12,000–18,000	..	2,700	..	..	1,550	400	800	..	..
Over 18,000	..	800	..	..	..	..	..	..	..
TOTAL ..	3,014,050	1,092,300	104,600	220,700	110,150	1,414,500	22,150	31,000	42,600

These do not include Greenland, Nova Zenilla, Spitzbergen and Iceland.

As far as can be judged from the world projections, the area of land surface above 600 feet is approximately 75% of the total land surface of the main vegetation zones, i.e., 38,474,000 square miles.

The land surface of the main vegetation zones are :—

North Arctic-alpine 6,146,000 square miles ; North temperate 11,525,000 ; North sub-tropical 12,210,000 ; North tropical 8,110,000 ; South tropical 7,605,000 ; South sub-tropical 5,208,000 ; South temperate 495,000 ; South Antarctic-alpine— ; Total 51,299,000 square miles. Or combining the equivalent zones in each hemisphere :—Arctic and Antarctic alpine vegetation zones 6,146,000 ; Temperate zones 12,020,000 ; Sub-tropical zones 17,418,000 ; Tropical zones 15,715,000 ; Total 51,299,000 square miles.

Some interesting points are obtainable from Table 1—(*a*) In Europe the largest land area is below 600 ft. (nearly 2 million square miles) and the next between 600 and 1,500 ft. (nearly 1 million square miles) ; (*b*) In Asia the largest land areas (all over $3\frac{1}{2}$ million square miles) are between 0–600 ft., 1,500–3,000 and 3,000–6,000 ft. ; (*c*) In Africa the land

areas up to 6,000 ft. are more easily sub-divided ($1\frac{1}{4}$ million 0–600 ft., $3\frac{1}{4}$ million 600–1,500 ft., 3 million 1,500–3,000 ft. and $2\frac{1}{2}$ million 3,000–6,000 ft.); (*d*) North America—the largest land areas are between 0 and 1,500 ft. ($2\frac{1}{2}$ million each between 0 and 600 ft. and 600 ft. and 1,500 ft.). About equal areas between 1,500 and 6,000 ft. (1 million 1,500–3,000 ft. and 1 million 3,000–6,000 ft.); (*e*) South America—the greatest land areas are between 0–3,000 ft. ($2\frac{3}{4}$ million 0–600 ft., over $1\frac{3}{4}$ million 600–1,500 ft. and slightly over 1 million 1,500–3,000 ft.).

The largest area of land between definite elevations as above is $14\frac{1}{2}$ million square miles between 600 and 1,500 ft., and the next, 14 million square miles between 0–600 ft., the two together representing rather over half the total land surface of the earth.

As regards watersheds, if we take tree levels in Asia at 12,000 ft. (it goes up to 14,000 ft., in the Western Himalaya) I have camped in Silver Forests at this elevation myself it is seen that Asia has the largest area of forest land between 6,000 and 12,000 feet amounting to 1,635,300 square miles.

It is here that some of the great Hindustan rivers rise and their tributaries—e.g., the Ganges, Jumna, the five Punjab rivers, Bias, Sutlej, Chenab, Jhelum and Ravi and the great Brahmaputra.

The importance of a knowledge of these elevations coupled with the known tree limits in the different regions of the world becomes at once significant. For they are linked up with the sources and early flows of the big rivers and their tributaries, in other words, with their catchment areas.

The following are some of the bigger (and one or two smaller European) rivers and the area of their catchment areas or drainage basins, length in miles and outflow :—

Comparative size of some of the Principal River Systems

River	Drainage Basin (Catchment Area) square miles	Length in Miles	Outflow
Amazon	7,050,000	5,500	N. Atlantic
Congo	3,700,000	4,640	S. Atlantic
Mississippi-Missouri	3,250,000	6,970	Gulf of Mexico
Rio de la Plata	3,100,000	3,880	S. Atlantic
Ob	2,915,000	3,640	Arctic Ocean
Nile	2,800,000	5,290	Mediterranean
Niger	2,800,000	4,160	Gulf of Guinea
Yenesei	2,570,000	4,750	Arctic Ocean
Lena	2,320,000	4,600	Arctic Ocean
Amur-Kerulen	2,080,000	4,480	Sea of Okhatsk
Yangtze	1,775,000	5,300	Yellow Sea
Mackenzie	1,660,000	4,600	Arctic Ocean
Volga	1,460,000	3,895	Caspian Sea
Zambesi	1,430,000	2,660	Indian Ocean
St. Lawrence	1,200,000	3,500	North Atlantic
Hoang-Ho	980,000	4,150	Yellow Sea

(*contd.*)

Comparative size of some of the Principal River Systems—(concld.)

River	Drainage Basin (Catchment Area) square miles	Length of Miles	Outflow
Indus	965,000	3,200	Arabian Sea
Orinoco	944,000	3,000	North Atlantic
Murray (Australia)	910,000	2,870	..
Danube	817,000	2,900	Black Sea
Brahmaputra	670,000	2,900	Bay of Bengal
Ganges	432,480	1,500	Bay of Bengal
Severn	4,350	210	Irish Channel
Thames	..	209	North Sea
Rhine	..	850	North Sea

A more detailed list of the rivers is given in Part II which should be referred to.

In connection with the rivers a detailed analysis of their Catchment Areas is required. In order to obtain this I addressed the following brief questionnaire to Forest Authorities throughout the world :—

(*a*) The names of the chief rivers in your country and their length in miles from source to mouth where they flow into the sea.

(*b*) The names of the chief tributaries of these rivers and the length of each tributary from source to where it joins the main river.

(*c*) The amount of forest still standing on the upper reaches in the mountains and hills of the main rivers from their source down.

(*d*) The amount of forest still standing on the main tributaries of each of the main rivers.

(*e*) What I mean by the amount of forest is really the area of the catchment areas which has been cut down or ruined by shifting cultivation and excessive grazing, and what area still remains forest.

Of course, I only want the above information in its roughest form ; in other words, the information which any Forest Officer acquainted with the region would be able to give.

The apparent fact and the dangerous position is that for the greater majority of the catchment areas no such analysis has ever been made. The Forester, understanding perfectly the question asked and the information sought, merely smiles and shrugs his shoulders ; or, in writing says that "the material has never been worked up for watersheds". Or, the common answer, "Your questions are somewhat of a poser—".

The answers which I am convinced it is necessary to obtain must be as clear cut as the following gives for the Pacific Cascade Drainages—Says the writer—

"It may be noted that in the Pacific Cascade drainages, with steep slopes and heavy rainfall but with about 90 per cent of the total area in forest, mostly dense,

floods and erosion are of no great cause for concern, while in the Colorado River Basin, with much lower rainfall but with less than one-third of its area in forest of a lighter type floods and erosion are serious". (A Watershed Protection Programme, by L. F. Watts, Director, North Rocky Mountains Experiment Station).

The type of information we require to know for each country and its rivers is exemplified by the following extract from a reply to my questionnaire given above by Professor Eino Saari for Finland :—

"Concerning the item of lumbering, shifting cultivation and firing, in catchment areas, we can tell you that Finland has almost not at all such areas, where the forests entirely had been destroyed through lumbering or forest fires. The lumbering is based almost without any exception on natural regeneration of the forest. The shifting cultivation and small forest fires can, likewise, be repaired by natural regeneration, and recently there has not been often large forest fires. So we can say that generally the whole original forest area is also now-a-days wooded, though on the other hand it is, of course, quite natural that the average growing stock per hectare on different areas are considerably variable. Especially we want to draw your attention upon the fact that in the east of Finland there has been shifting cultivation rather lately, and it has done that the quality of the forest has been changed for the worse. Also the growing stock per hectare have become smaller, though there will not be absolutely waste areas".

This for a temperate, well forested country ! Other Western European countries could doubtless give equally well informed particulars of their regions. But here we are concerned with the world outside Europe.

Considerable investigation work has been carried out into stream flow and erosion in the United States as exemplified by the North Rocky Mountains and Ranges Experiment Station and others. We understand, it is said, the problem so far as the inimical effects of serious interference with the soil covering in the catchment areas of our water supplies ; but it appears a curious thing that no effort even for one whole country, much less a world effort, has ever been made to examine and record the present position and condition of the catchment areas of rivers great and small, including streams and springs ; with the exception of some of the European countries whose work in these matters is well known. Therefore, Western Europe is omitted from the notes given here.

I wrote to most of the Forest Authorities in the rest of the world in order to ascertain what information was available. I was fully prepared to find the available knowledge of the catchment areas scanty, but I have been rather staggered at the gravity of the position. "All the Federal Agencies with which I have talked", wrote a friend from the United States, "tell me that the material has never been worked up for the watersheds in the way that would be helpful to you".

It would appear that the great work which has indubitably been done in connection with erosion and possible methods of checking it, usually starting on the lower ground or at the lower elevations has captured the attention of forester, engineer and agriculturist, and that only small efforts have so far been made to understand the true position up in the catchment areas.

I submit that until we know the true position of the catchment areas of the rivers and streams of the earth, we shall not be in a position to speak about the water resources and possibilities of the world.

I was consulted a few years ago about a great irrigation scheme for the irrigation of a large area of barren, degraded country. Not only was the great river to be harnessed but the engineers had examined every small stream and rill, the runoff from bare rock after rain storms and included all these amounts into their calculations of the annual supplies. Every drop of water on the country-side, it was said, had been measured and calculated and the total amounts available for the project per year were based on the calculations. Most of the hill-tops and small mountains were bare of vegetation. Serious floods which destroyed roads, bridges, habitations and so forth, occurred periodically. Under existing conditions, and others outside the engineer and the country in question's power to deal with there could be no certainty of the calculated volume of water being available for a calculated series of years. In fact, very much the opposite !

And yet, how many schemes for the supply of water to great cities and people throughout the country-side, to provide power for industry and so forth, are based on water supply systems for irrigation or power of which we know little.

Similarly, how can there be any certainty or security when the real data such as we foresters are only properly qualified to obtain from the field and then work up, are mostly non-existent, "The material has never been worked up for watersheds" ! To my enquiries I have had this reply more than once. But though the figures which are now so important to work up are not available, the United States, in a tabular statement entitled "Watershed—Protection Value of Forests in the United States" has some interesting figures for the three main drainage systems, East Mississippi River Basin and West.

Drainage	Total Land Area	Total Forest Area	Forest Area by Watershed Protective Influence		
			Major	Moderate	Slight/None
	Thousand Acres	Thousand Acres	Thousand Acres	Thousand Acres	Thousand Acres
East	480,130	245,001	73,249	40,005	122,747
Mississippi River Basin ..	788,155	172,201	103,545	36,169	32,487
West	1,903,291	614,558	308,036	140,741	165,781

The Pacific Cascade in the West Drainage above has been already alluded to. The figures actually show the following :—

Total area of land (in thousands of acres) as 31,648 ; total area of forest 26,487 ; major forest protected area 15,554 ; moderate forest protected area 9,509 ; slight to no protection 1,414. *About 90% of Catchment Area protected and floods and erosion of no great concern.*

There can be little doubt that our ignorance on the catchment areas has been largely due to the ignorance and apathy of the Civil Authority in different countries, and the paucity of Forestry Staff maintained in most. Every forester is acquainted with the reasons—unwillingness of Governments and their representatives, Governors and so forth and of the civil officers under them, to interfere with the customs and habits of teeming millions of peoples whose thoughts, standards of living and so forth are very different from the more highly civilized races. To this, add ignorance of Nature and her fundamental truths, powerful tested interests in over-exploiting forests and over-grazing and the present position is undersvandable.

There is the graver side. The more modern recognition of the value of the river systems, but solely from the view point of what they can and must do for the modern requirements of man—great reservoirs of drinking water and for cleansing of towns, water for power for industry and lighting, and water for irrigation. These are recognized by all.

In a recent debate on river-flow (River-flow Survey and Records) held by the Royal Astronomical Society at Burlington House, London, in January 1949, the fact was abundantly evident that the rivers and their big tributaries were regarded in the discussion solely from the above points of view, that floods were accepted as a matter of course, Act of God, or caprice of Nature. Owing to the importance of rivers in providing the necessary water for industrial development, apart from its scientific interest an accurate knowledge of river-flow is, it was said, of great importance. "The minimum flow is of special significance, for it determines the amount of water available for industrial purposes, and limits the amount of effluent which may be discharged without excessive contamination. In areas troubled by flooding the maximum flow is also of obvious importance". The investigation discussed were confined mainly to Great Britain. "Actual precipitation over a given basin can usually be determined within a few per cent but to derive the runoff in the river requires in addition, a knowledge of storage and evaporation, neither of which are accurately known". We are not concerned here with the methods selected for the determining of river-flows at different seasons of the year. The remarkable feature of the debate was that no reference was made to the catchment areas of the rivers concerned or any river. The factor that a river could be controlled and with it the current and volume at different seasons if a return to Nature and a sufficient vegetation covering was restored in the catchment areas was not mentioned and appeared to be quite unknown to the meteorological experts who took part in the geo-physical discussion.

The fact that this is a world problem was not understood. A member pointed out that the avarage flow of a river gave little useful information and that it was important to know the fluctuations. The Zambesi Falls were given as an example. Here the average ratio of maximum to minimum runoff is about 30 to 1, which makes the Falls almost useless as a source of hydro-electric power. The Zambesi River as has been shown has a length of 2,660 miles with a drainage basin of 1,430,000 square miles. It is estimated that there is 20% of fringing forest and 30% of fringing scrub along the banks of this river. The discussion at the meeting was concerned with the different methods of measuring the flow. No mention was made of the possibility of the flow seriously decreasing in the future.

Herein lies the greatest danger to the world at the present day. The idea that the volumes of water in rivers and streams can be measured at their present rates of flow and that these values and flows may be regarded as permanent !

How many foresters have preached on this theme ? And how many Governments and their responsible Civil Officers have ignored the warnings, to go no further back than during the past half century !

Here is an example, one of very many, from Northern Rhodesia, a country with important mining communities. Enquiries were made on the subject of the amounts of fringing forest and fringing scrub on the rivers. The reply "I am afraid you are asking for more than we can supply. This is an immense country and part of its rivers have never been traversed. Rough estimates of the main rivers are as follows :—Zambesi, as already given ; Luangwa, length 520 miles, fringing forest 30% fringing scrub 10%. Kalompo, length 310 miles, fringing forest 30%, fringing scrub 20% ; Kafue, length 740 miles, fringing forest 20%, fringing scrub 5% ; Luspula, length 380 miles, fringing forest 20%, fringing scrub 20%.

Not a very encouraging prospect for Northern Rhodesia.

An attempt has been made to obtain information on the forest position as a forester could easily portray it if the position of the catchment areas of important rivers (important to their several regions) throughout the world was known to him. It has proved an interesting study if only from the point of view of the extra-ordinary meagreness of the amount of information available.

In a paper of this kind little more can be done than to condense as concisely as possible what appears to be the more striking or the more serious items of the information obtained.

For example in the case of Northern Rhodesia and large areas of Africa, it is important to know what areas of the country are subject to shifting cultivation and unchecked grazing under which practices vegetation and covering are gradually removed, top-soil disappears and desert supervenes. That such an enquiry is informative is shown by the present talk of part of Africa being a future beef producer. Where is the water coming from on these enormous scrub forest areas, yearly becoming more desiccated ? What is the condition of the forest in the catchment areas of the rivers ? Or of that so termed fringing forest along the river banks ? For long it was respected and guarded by the local villagers and the Chiefs—with increasing pressure of population and a degraded scrub producing smaller crop returns, the fringing forest is threatened just as the forest in the catchment areas is gradually becoming more and more restricted by unchecked felling and grazing.

On the other hand there are great forests, mostly tropical and sub-tropical (and omitting the great tract of soft wood mainly coniferous forest in North Russia and Siberia) which so far have been inaccessible to the timber exploiter which in some cases (South America for instance) may have the head waters of their rivers intact and the volume of water in the river fairly stable the year throughout.

Two smaller instances may be mentioned here. Both in British Honduras and British Guiana. Of British Honduras, Mr. A. L. Lamb, Conservator of Forests writes—

> "Ninety-three per cent of British Honduras is still under forest of one kind or another including pine savannah forests and the upper reaches of all the main rivers of the Colony and their tributaries are 100 per cent forested".

For British Guiana, Mr. Swabey, Conservator, gives much the same report. The catchment areas of the chief river Essequibo and its tributaries are mainly under virgin, untouched forest. Mr. Swabey concludes his report with the words—

> "Finally, to sum up, there is at present no abuse whatsoever of protection forests in British Guiana and the effect of man on the hydrologic balance is absolutely nil".

This is the type of information, succinct and to the point we want for the whole world.

Then the forester will be able to get to work on what is now-a-days undoubtedly one of the great and urgent world problems of survival.

As an example of the lines upon which this forest problem has been dealt with effectively on a large sub-Continent, India, and saved a great population from a forest produce famine, which would assuredly have commenced at the beginning of the present century and which the two great wars of the century would have greatly intensified in a greater part of the country, under India in Part II, I give an analysis of the way the forests were preserved by the British Government of India.

It will be of interest here to give a few of the earliest of the experiences due to accelerated overfelling in the accessible forests owing to the introduction of an orderly and peaceful administration, followed by a rapid increase in the native population and its requirements.

These were the first recorded experiences of tropical forests and the effects of their unchecked exploitation.

Our (British) first knowledge of the fact that no forest was inexhaustible and of the instability of overcut areas in the tropics was acquired in the Madras and Bombay Presidencies of India during the first half of the nineteenth century. In 1848 Dr. Gibson, Officiating Conservator of Forests (Bombay) and Blane, District Civil Officer, pointed out that the extension and rapid clearance of the forest in Canara had resulted, it was alleged, in much less rain falling than in former years, when the country was covered with woods ; whence it was supposed that the gradual filling up of the mouths of the large rivers, which was observed along the whole length of the coast, was in a great degree attributable to the decreasing body of water which flowed from the upper country, and by the force of which the silt was previouslly carried into the sea, and the channels of the rivers kept deep. To show the rapidity with which the woodland in Canara had been destroyed, it was stated that within thirty or forty years the forests had receded from the coast to within a few miles of the Ghats, and large tracts of country were instanced which were formerly within no distant time covered with wood, but which now had hardly "a stick large enough for firewood". The improvidence with which the wood was treated, every tree and bush being felled at first, and the shoots and saplings which would have grown up and supplied their places being cut down every year until the roots die off, leaving nothing but the bare laterite hills which will remain for ever afterwards utterly sterile and useless.

The other striking point in this early forest administration was the concensus of opinion behind the Civil and Forest Authorities on the dangers of uncontrolled shifting cultivation (*kumri*). Blane and Gibson drew attention to the destruction caused to forest land by this type of cultivation. This destruction (in 1848 over a century ago) was said to be then confined to the neighbourhood of the Ghats, because it was there alone that any forests remained. It was carried on with such increasing activity every year as to bid fair to destroy the whole of the large virgin forests in a short time. Blane stated that the practice was so wasteful and improvident that it ought not to be tolerated excepting in a very wild unpeopled country, and he was of opinion that it should be placed under considerable check and regulation, if not entirely prohibited.

Here is another picture of these early days. The slopes on the west coast of the Bombay Presidency were once, even in the early days of British occupation, covered with magnificent, valuable and extensive teak forests. These have long since been cut out. The denudation of the Deccan Highlands and the Eastern Ghats has resulted in the gradual silting up of the rivers. When the Dutch, French and English first built settlements on the Coromandel Coast, it was possible to take ships up the Godaveri and Kistna. The English port of Narasapur and the French one of Yanaon, both on the Godaveri, were once the chief ports of this coast. They can now only be reached at high tide by small native, shallow-draught craft. At Masulipatam the Dutch ships used to anchor close up to the port, whereas at the present day even small native vessels have to anchor five miles out in the roads. A century ago the town and port of Ganjam were places of considerable importance on this coast. Small sea going vessels used to cross the bar of the river and lie at anchor opposite the fort. An inspection now-a-days will show that there is scarcely two feet of water at this spot in the dry season. The writer (in 1903) shot wild fowl in marshed in the vicinity in places where in olden days vessels rode at anchor. All these examples are on the east coast of Madras, the silting up of the rivers and the decrease in the water supply being due to the destruction of the forests on the Eastern Ghats.

Dr. Gibson enumerates in one of his first reports on the forestry question in the Bombay Presidency a list of the rivers and creeks on the Malabar coast where on our arrival in those

parts ships used to ride at anchor, all the creeks having silted up within the memory of men then living.

The illustrations given are perhaps sufficient to depict the position of affairs and the opinions held on this matter in the earlier portion of our rule in India.

On Dr. Cleghorn's (Conservator of Forests, Madras Presidency) initiation at the Meeting of the British Association in Edinburgh in 1850 a Committee was appointed to consider the Destruction of Tropical Forests in India. A report was drawn up and presented at the Association's Meeting in the following year at Ipswich. It was the first report of the kind ever written dealing with what may be determined the economics of the Tropical forest and how through ignorant treatment, Nature's balance may be easily upset.

By 1850 the Government was becoming seriously alarmed at the obvious destruction taking place from these unchecked or uncontrolled factors (*i*) uncontrolled fellings ; (*ii*) uncontrolled shifting cultivation and (*iii*) uncontrolled grazing in the forests and on the countryside, accompanied by firing of the countryside. The grazing was only slowly comprehended because it was the natural method of pasturage of the population and the enormous increase in animals (the wealth of the village) with an orderly government had not been foreseen or even thought of. The warnings of Blane and Gibson and others were now beginning to be taken seriously.

But there was another side to these problems. With the object of developing the country, both in Ceylon and Madras in about the thirties of last century the Governments concerned commenced to encourage the planting of coffee and tea and gave grants of areas from the tropical forests for the purpose. It is as we know now, a mistaken idea that the tropical forest soils will continue almost indefinitely to provide new land for colonization. This type of forest and soil requires a careful treatment. It is a very delicate organization and the action of man may be opposed to Nature, who holds the scales. It was in areas of this type of forest given over for planting that the lesson was learnt in Madras, by the Forester at least. Captain Beddome, Conservator of Forests, wrote as follows in 1876 :—

> "The planters who come over from Ceylon are now giving a very high price for land, and the whole mischief may be effected in a very short time. It must not be supposed that coffee is at all a permanent cultivation : we have only to look at the Sampajee Ghat in Coorg, the Carcoor Ghat and many other places in the Wynaad, the Sispara Ghat on the Nilgiris, and parts of the Annamalais, to see at once that it is very often very little better than the *Kumri* (shifting cultivation) of the hillmen. The list of deserted estates is, I fancy, much greater than that of estates kept up, and if it had not been that the price of coffee suddenly doubled itself a few years ago, there would be hardly any of the old estates kept up at all, at least in North Wynaad and Coorg ; it pays a coffee planter to take up a tract of primeval moist forest on our mountain slopes for a few years ; he gets bumper crops the 3rd, 4th and 5th years, but denudation of the soil goes on rapidly, and it does not pay him to keep it up many years. Can we restore the grand old forest with all its climatic influences ? A thorny wilderness takes its place" !

It is nearly a century since this lesson was learnt in India. Yet how has this type of forest fared since in other parts of the world ? How is it being treated at the present day ? And how will this type be treated in South America now that the tropical forests of that great region are coming under exploitation !

Erosion and its effects in Madras and Bombay Presidencies have been mentioned. By the close of the nineteenth century four lessons on this important subject had been learnt in Northern India especially in the Punjab foothills. The celebrated Hoshiarpur Chos and its erosion damage was being quoted by the eighties of last century. In the Hoshiarpur

District of the Punjab, the Siwalik range of hills stretches from the Beas to the Sutlej River in a south-easterly direction. These hills consist of a very friable sandstone, alternating with strata of loam and clay. Formerly these hills were fairly well wooded. In 1846 they became British territory ; with the rapid increase in population which followed, a great demand for wood and charcoal ensued for the requirements of the population of the fertile plains below, whilst the hills were invaded by a considerable population of graziers with large herds of cattle. The result was complete denudation of the hills ; the loose soil, no longer protected by vegetation, was washed down, broad stretches of sand invaded the plains beneath, with the consequence that the arable lands of 940 once prosperous villages were covered with sand which laid waste upwards of 70,000 acres of fertile lands. By 1900 this formerly rich district was traversed by numerous broad, parallel, sandy belts, cut out of the fertile and crop-bearing area. Proofs of the advantages accruing from the strict protection of areas where erosion had resulted in annually increasing damage, with its many attendant consequences, were not, therefore, absent by the close of the century. In almost every instance protection from fire and grazing was almost immediately followed by the growth of a dense vegetation which soon checked erosion and reduced the danger of landslips and sudden floods ; the beds of streams debouching from fire-protected areas soon began to contract in width and flow in narrower and better defined channels. Generally in Northern India by the end of the century the Forest Officer could show evidence of the results of strict closure and fire protection. The following is an example—The influence of protection on the continuity and supply of water in springs, tanks (reservoirs) and wells showed the most divergent results. In some places a continuity and regular supply of water followed protective measures, whereas in others an immediate decrease of the water supply took place. These phenomena had been foreseen. In the case of the tank, for instance, where the maintenance of the water-level depended upon a rapid flow into it, which resulted from rainwater falling upon and rapidly running off a bare piece of ground, a covering of vegetation on the area naturally interfered with this rapid flow. The tank had been built to replace the dried-up streams and springs formerly existing on the area when it was covered with vegetation. These streams provided, naturally, moisture to the area which now had to be irrigated by raising the water from the tank by the labour of man and distributing it over the land. In the case of protective measures introduced with the object of restoring the natural water supplies, time is required before the sub-surface flow of water can regain its proper level, and the experiments made up to this time were still too recent to afford reliable results. Ribbentrop mentions, however, that water had already been found near the fire-protected Danta Reserve in Ajmere at a depth of fifteen feet, whereas under very similar conditions as regards rock, stratification and soil, but where the hill-sides were bare of vegetation, water was not reached under a depth of twenty-five feet (1899). During the next twenty years further definite evidence became available on this subject.

As regards shifting cultivation or farming as it is termed in West, Central and East Africa, the baneful results to the country at the present day are becoming more generally known. In early times this method of agriculture as developed by the African was probably the best possible with the facilities at hand. Moreover, he knew a certain amount about the conditions of the forest and soils. Given a static population at the beginning of the twentieth century it is possible that the practice might have continued fairly extensively for a considerable period ahead. But the heavy increase both in population and their flocks, grazing and browsing animals, have completely altered the position and threaten famine, migration or extermination to large numbers of human beings and their herds and flocks.

In Part II the replies to the questionnaire will be now considered.

[*continued*

A SCHEME FOR PARTIAL ENUMERATIONS IN THE HILLS

BY S. K. SETH
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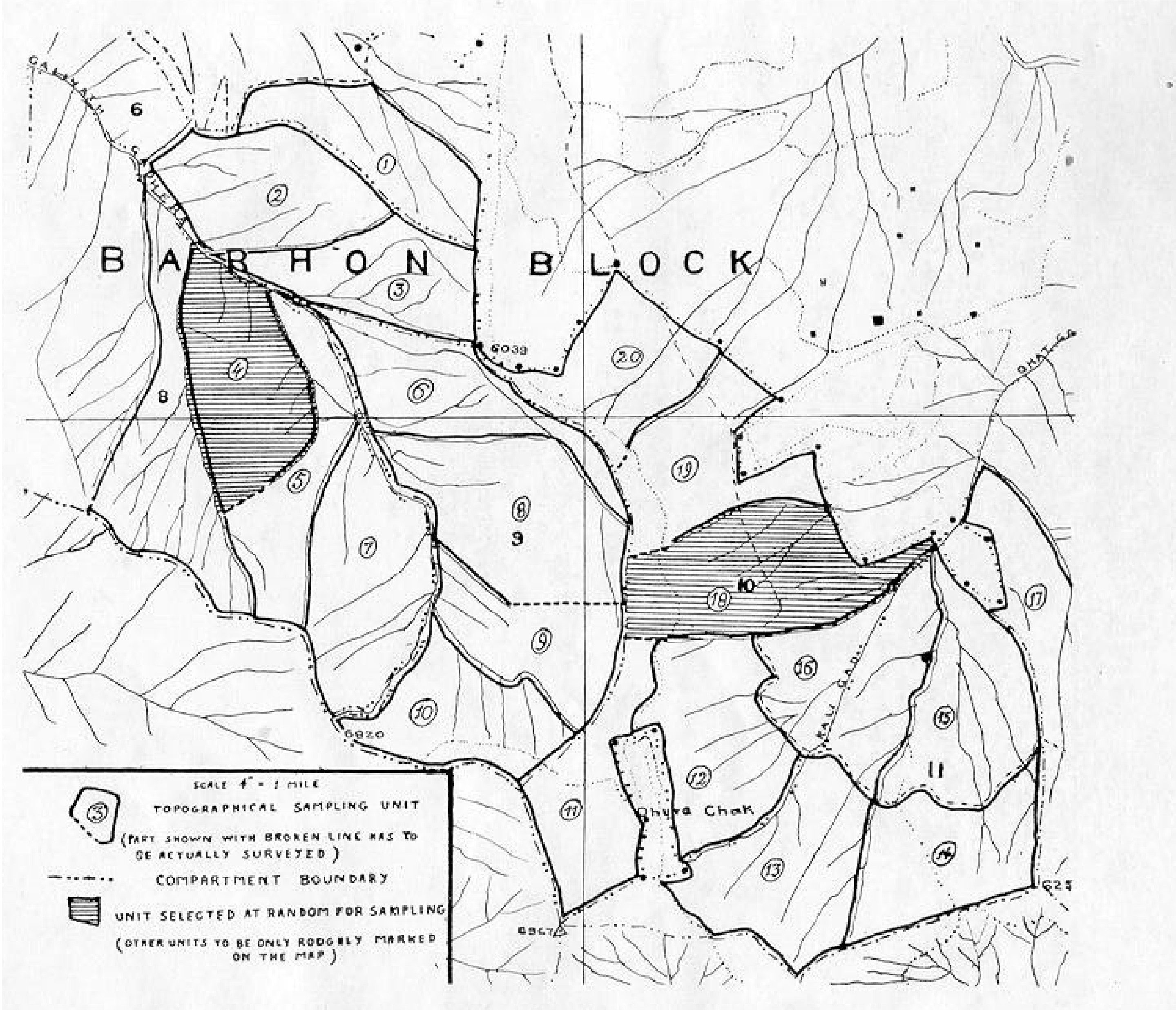
SUMMARY

Orthodox sampling methods used in Forestry depend upon accurate survey to locate and demarcate the sampling units. This item is chiefly responsible for the disproportionately large amount of time and money required for partial sampling as compared to total enumerations over whole compartments. A method is described which dispenses with survey almost altogether as it makes use of the detail given in large scale survey maps both to locate the sampling units on the ground and to determine their areas accurately. Its chief utility lies for sampling in the hills because it is possible to mark out comparatively small (30–75 acres) sampling units on survey maps. Stratified sampling with enumeration of two sampling units per block is advocated and the expression for calculating the fiduciary limit of the mean growing stock per acre is given. The question of weightage to allow for differences in areas of sampling units is discussed.

1

All sampling methods at present in use in forestry, whether systematic or random, are either survey methods in which data are collected along parallel strips laid out in a constant compass direction, or sample plot methods in which data are collected on plots of regular shape and size, or a combination of both. Partial sampling by only 1 or 2 chains wide strips, by circular or square plots from 1/10th to 1/5th acre in area, and by line-plot surveys in which the regular plots are laid out at random or predetermined intervals along equidistant and parallel lines laid out in a systematic pattern are familiar examples of these methods. Except for general planning, detailed maps are not necessary for successful application of these methods as correct survey to locate the lines or plots or both for sampling purposes is an essential feature of the sampling itself.

Even if accurate large scale maps showing natural features in considerable detail are available, they can not be put to much use, except for determination of the gross area sampled and location of points of reference, which purpose is equally served by maps showing much less detail. In fact a compass survey can not be avoided, and this together with the fact that enumeration of growing stock has to be done by skilled labour on plots or strips which have to be *accurately surveyed and demarcated on the spot* is chiefly responsible for the high cost and relatively much more time required in partial sampling as compared to total enumeration of compartments or sub-compartments. It has been estimated on the basis of work done in this state that to cover equal areas, systematic partial strip sampling to 20% intensity takes more than twice as much time and four times as much money as total enumerations. This disparity is largely attributable to the survey operations involved in partial enumerations and if these can be eliminated considerable saving in time and costs would result. If these orthodox methods are applied in hilly terrain, the disparity increases, quite apart from the arduousness (and sometimes the sheer impossibility) of conducting such surveys. The only feasible method for partial sampling in the hills is, therefore, one which dispenses with survey altogether and relies on the detail given in existing maps, both for accurate computation of the area of the sampling unit and its delimitation on the ground. Such a method based on the concept of "topographical sampling units" is described below.



BARHON BLOCK
6033
6820
6967
SCALE 4" = 1 MILE
TOPOGRAPHICAL SAMPLING UNIT
(PART SHOWN WITH BROKEN LINE HAS TO BE ACTUALLY SURVEYED)
COMPARTMENT BOUNDARY
UNIT SELECTED AT RANDOM FOR SAMPLING
(OTHER UNITS TO BE ONLY ROUGHLY MARKED ON THE MAP)
Dhyra Chak
KALI GAD
GHAT GA

2

A "topographical sampling unit" may be defined as a sampling unit of irregular shape and indefinite size (within certain limits) whose boundaries are for the most part topographical in character and which can be located on the ground with reasonable exactitude by a reference to the 4″ = 1 mile scale survey map of the area. Such easily distinguishable features are streams, *nalas*, and tops of ridges. Of course, in actual practice many sampling units will also include artificial features like roads, inspection paths, block, compartment or coupe boundaries, as part of their boundary system and it is in fact desirable to take advantage of them to the maximum possible extent (if they are known to be accurately shown on the map) to increase convenience of working. In some cases existing natural or artificial features may not wholly cover the entire perimeter of a desired sampling unit in which case the gap has to be filled by survey and plotting on the map. By working on 4″ = 1 mile scale maps of many hill areas in this state, it has been determined that sampling units of from 30 to 75 acres can be conveniently located. To start with the area to be sampled is divided into a number of convenient units on the map. The units are then stratified into *homogeneous* blocks of requisite size such that the enumeration of 2 units per block yields the desired intensity of sampling. This method ensures stratification into blocks containing the smallest possible number of units such that precision can be calculated. The smallness of blocks allows considerable dispersal of units actually sampled over the whole area and, therefore, a relatively more representative sampling. The 2 units per block to be actually enumerated are selected at random.

3

The fiduciary limits of mean growing stock per acre (Y) at the desired level of significance can be calculated by the following formula :—

$$Y = Y_0 \pm \left\{ \sqrt{\frac{V}{2N}\left(1 - \frac{1}{r}\right)} \right\} t$$

where Y_0 is the mean growing stock per acre derived from the samples enumerated.
V is the pooled variance, i.e., the mean of the individual block variances.
r is such that the sampling intensity is 1 in r.
t is the value of t at the desired level of significance for N degrees of freedom.
2N is the number of samples, taken out of N blocks.
Total variance for each block = $\frac{1}{2}$ ($y_1 - y_2$).
where y_1 and y_2 are the mean growing stock per acre for the two samples, whence

$$N.V = \sum^{N} \tfrac{1}{2} (y_1 - y_2)^2.$$

Since the sampling units are unequal in area, it is necessary to calculate the weighted mean for each sample and the weighted block variances. Schumachar and Chapman discuss a method of calculation of precision of the weighted mean for strip sampling of irregular blocks, using lengths of strips as weights, in section 7·5 of Chapter 7 in their "Sampling methods in Forestry and Range Management" (Duke University, Bull. No. 7). The expression derived by them for the individual block variance is

$$\left(2 + \frac{w_2}{w_1} + \frac{w_1}{w_2} \right) \left\{ x_1 - w_1 \left(\frac{x_1 + x_2}{w_1 + w_2} \right) \right\}$$

Where x_1, x_2 are the total volumes on the two sampling units per block and w_1, w_2 are their weights. If weights are made proportional to areas, this expression can be used for the scheme outlined here. However, since there is some doubt about the validity of the assumptions involved in the derivation of this formula, it is perhaps better not to correct the individual block variances for weights, if the areas of the sampling units are approximately equal.

MORE TREES MEAN MORE FOOD

BY T. JEYDEV, B.SC. (HONS.), A.I.F.C. (HONS.)
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On the 1st July 1950 we celebrated all over the Indian Republic, '*Vana Mahotsava*' with a national zeal characteristic of a free nation. The ceremony went off with great eclat and it is worth while to deliberate the reasons for celebrating the festival of trees.

Briefly stated the main reasons are :—

(1) to impress upon the public the importance of forests and to develop an attitude of reverence and sacredness towards the Tree—the real staff of our very existence,

(2) to replenish to a certain degree the destruction which the improvidence of Man had wrought on the forests in the recent past and

(3) to aid our arduous task of growing more food to feed the growing population.

From time immemorial trees have been revered by one and all. The importance of the tree for the well being of Man had been recognized both by the Sage and the common man and different species of trees were worshiped in different countries. When wooded lands were in plenty, little thought was given to any destruction of a portion of forest land because the evil that resulted was insignificant. The needs of a growing population and the requirements of timber and fuel for a host of purposes in modern civilization have made the axe fall heavily on the wooded wealth of the nation and the grim struggle for existence had brushed aside the sentimental regard for the tree. The time has come to cry a halt to the vandalism which man unknowingly had caused. Efforts made by the State to preserve the forest wealth of the nation would not be of much avail if the man in the street is not made to realize the value of the tree. The sagacity of Shri K. M. Munshi the Hon'ble Minister for Food and Agriculture to the Government of India had conceived the magnificent idea of celebrating the festival of trees with such grandeur as to catch the imagination of the common man and to restore the spirit of reverence towards the tree. When the country becomes tree conscious and forest loving, the significance of keeping a certain portion of the land for conservation by the Forest Department will be appreciated by everyone.

The relation between Food and Forests may appear paradoxical but nothing is more dependant on the other, than Agriculture on Forestry. For growing more food two important conditions are essential, viz. (1) good soil and (2) sufficient moisture. Without a good forest canopy well distributed at least over 25% of the country, it is not possible to conserve the necessary moisture which the seasonal rainfall showers on us and all our attempts at growing more food will be set at naught if it is without this fundamental appreciation of the necessity to retain sufficient moisture to sustain the food crops. Without the forest lands to arrest the run off and thereby protect the loss of fertile soil by erosion, diminishing yields will result because of the impoverished soil and arid conditions. Forests conserve the moisture obtained from rainfall and feed the springs and rivulets gradually and steadily so that permanent sources of moisture are rendered possible. Forests serve the needs of the agriculture adjoining it by giving the cultivator his requirements and by affording his cattle ample pasture. Forests provide means to replenish the impoverished soil with green manure and help the cultivated lands to maintain the texture of soil by warding off the evils of erosion. Though the Forest Department is conserving the forests under its charge, the percentage of really wooded tracts is not sufficient to confer on agriculture to a full measure the benefits of

forests. If more lands come under more trees, leaving the optimum acreage for cultivation more food per acre would result. Unless the green glory that was, is restored as speedily as practicable there is no escape from stark hunger stalking the land. When forests go, fertility departs and pestilence follows. Much of our wooded land under private control had been ruthlessly exploited recently and the general denudation of tree growth had affected food production and made famine to show its ugly head. The impoverishment of soil by repeated cropping and the growing population of the country had created a food problem, which we have to solve if we have to live. The conditions that are essential for growing more food are so intimately connected with forestry that we must see that the lands under good forests are maintained carefully and where they are not and where they should be grown, intensive efforts at afforestation should be made. The scale in which the Forest Department had been doing planting work in the past had been stepped up all over the country for meeting the demands of the public for a variety of purposes. But the incessant cry from the public for disreservation of forest areas to bring more land under cultivation is a pointer to show that many have not yet realized that they are destroying the very source of food in the name of more food. The people who want more forest lands to be brought under the plough must realize that the cry for disreservation is only an easy escape from a difficult situation which should really be tackled by maintaining optimum percentage of land under forests and devising ways and means to improve the yield per acre by intensive cultivation. The ruthless and indiscreet destruction of forests have made the deserts to advance, the sources of moisture to dry up and the fields to go barren. The choice before us is either "Trees or Famine". Unless we grow more trees we cannot stave off hunger from this land.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*a*) (Graphical Method)

(*Continued from the* "Indian Forester", *November 1950, page 486*)

Design for a timber bridge of span 40 feet, width 10 feet to take I.R.C. 'B' class loading, timber used being sal (*Shorea robusta*). Grade of timber being structural No. 2 conforming to standard grade.

(A) Design of Decking :—See Fig. 65.

Use main decking of 3″ thickness and over it at right angles place planks $1\frac{1}{2}$ inch thick nailed down to main decking to take wear and tear of traffic. (Design followed as per design of decking in Part III).

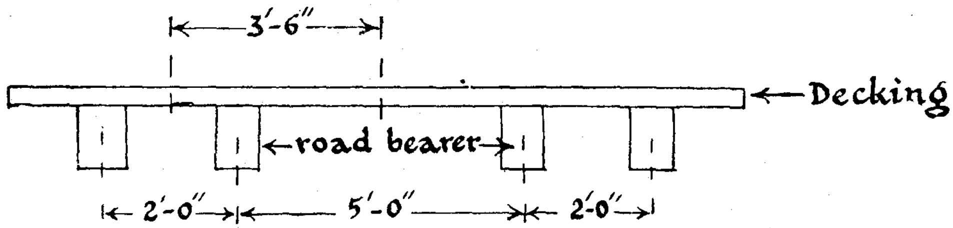


fig. 65.

(B) Design of Roadbearers :—See Figs. 66 and 67.

From Figs. 66 and 67 it is evident that effective spans of roadbearers are 5′ 0″ and taking for granted that we will make use of timber of minimum length (here 5′ 0″). [Although timber in lengths of multiple of 5′ 0″ will give continuity of span over supports (here as transoms) and could thus be a more economical design].

(1) U.D.D.L. due to 0·34 ton per linear foot of each traffic lane over 5 feet span and 3′ 6″ width (Fig. 65) is

$$W_1 = \frac{0\cdot34 \times 2240}{10} \times \frac{(5 \times 3\cdot5)}{1} = 1339 \text{ lb.}$$

(2) Dead weight of decking $= \frac{5}{1} \times \frac{4\cdot5}{12} \times \frac{3\cdot5}{1} \times \frac{60}{1} = 394$ lb. coming over one roadbearer marked 'R'

$\therefore W_2 = 2 \times 394$ considering prolong duration of dead loads

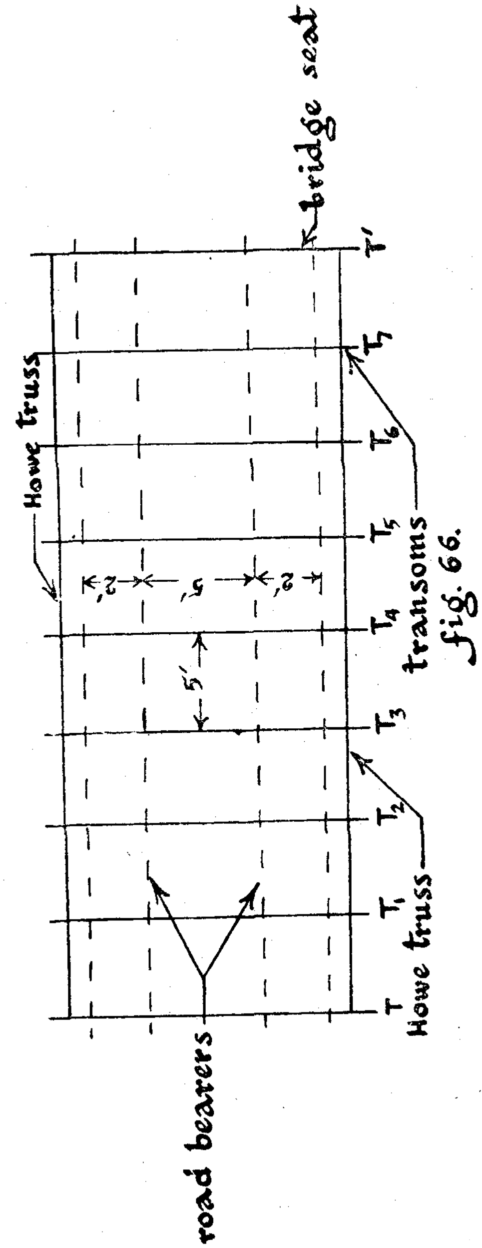
$\therefore W_2 = 788$ lb.

(3) Dead weight of one roadbearer assuming it to be 5″ × 4″ section

$$= \frac{5}{1} \times \frac{5}{12} \times \frac{4}{12} \times \frac{60}{1} = 62 \text{ lb. (approx.)}$$

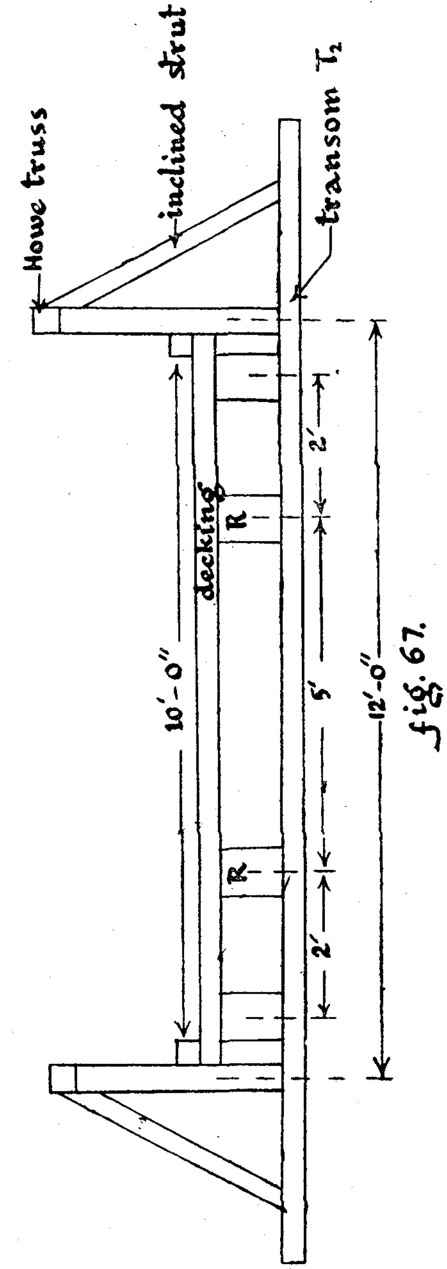
$\therefore W_3 = (2 \times 42)$ lb. considering prolong duration of dead loads

$\therefore W_3 = 84$ lb.



bridge seat
Howe truss
transoms
Howe truss
road bearers
T
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T'
2'
5'
2'
5'

fig. 66.



Howe truss
inclined strut
transom T_2
decking
R
R
10'-0"
12'-0"
2'
5'
2'

fig. 67.

(4) $\therefore$ Total distributed dead loads on one roadbearer 'R' (Fig. 65) is

$$W = W_1 + W_2 + W_3 = 1339 + 788 + 84$$
$$= 2211 \text{ lb.}$$

(5) Max. B.M. due to (4) $= \frac{WL}{8} = 2211 \times \frac{(5 \times 12)}{8}$

$$= 16575 \text{ in. lb.}$$

(6) U.D.D.L. due to 6 tons knife-edge load per traffic lane and considering this on 3·5 feet (see Fig. 65) is

$$W = \frac{6 \times 2240}{10} \times \frac{3 \cdot 5}{1} = 4704 \text{ lb.}$$

This W travels as a point load from one end of roadbear to another end, producing max. bending when W is at midspan of roadbearer.

(7) $\therefore$ Max. B.M. due to (6) $= \frac{WL}{4}$ (concentrated load condition)

$$= \frac{4704 \times (5 \times 12)}{4}$$
$$= 70560 \text{ in. lb.}$$

(8) Total max. B.M. due to (5) and (7) is

$$B.M._{max} = 16575 + 70560$$
$$= 87135 \text{ in. lb.}$$

(9) Assuming width of roadbearer to be 4″

$$B.M. = fZ$$
$$87135 = 2400 \times \frac{bd^2}{6}$$
$$\therefore d^2 = \frac{87135}{24000} \times \frac{6}{4} = 54 \cdot 4 \text{ (approx.)}$$
$$\therefore d = 7 \cdot 4 \text{ inches (approx.)}$$

Use sections of roadbearers each equal to 8″ × 4″.

(C) Testing of Roadbearers against Shear :—

(1) Max. shear due to 0·453 ton per linear foot of each traffic lane is

$$S_{max} = \frac{1339}{2} = 669 \cdot 5 \text{ lb.}$$

(2) Shear due to 6 tons knife-edge load per traffic lane is

$$S_{max} = 4704 \text{ lb.}$$

(*Note.*—Here the whole knife-edge load of 4704 lb. acting at one end of roadbearer produces max. shear of the same value).

(3) Max. shear due to weight of decking (12″ × 4·5″) and one roadbearer of 5 feet span and section 8″ × 4″

$$S_{max} = \frac{394 + 67}{2}$$
$$= 231 \text{ lb.}$$

(4) Total max. shear $= 670 + 4704 + 231$

$$= 5605 \text{ lb.}$$

$$\therefore \ s_a = \frac{5605}{8 \times 4} = 175 \text{ lb./sq. in.}$$

(5) Now $s_m = \frac{3}{2} s_a = \frac{3}{2} \times \frac{175}{1} = 262$ lb./sq. in.

Since actual $s_m >$ permissible s_m for sal which is 180 lb./sq. in., therefore, section of roadbearer 8″ × 4″ will fail against shear.

(6) Use a larger section, say 10″ × 5″

$$\therefore \ s_a = \frac{5605}{10 \times 5} = 112 \text{ lb./sq. in.}$$

$$\therefore \ s_m = \frac{3}{2} s_a = \frac{3}{2} \times \frac{112}{1} = 168 \text{ lb./sq. in.}$$

Now actual $s_m <$ permissible s_m for sal which is 180 lb./sq. in.

Therefore, use roadbearers each of section 10″ × 5″ which will be strong against bending as well as shear.

(D) Testing of Roadbearers against Deflection :—

As per method shown in Part I, it will be found that section 10″ × 5″ of Roadbearer of span 5 feet each is safe against deflection also.

(E) Design of Transom at 'T_2' :—See Figs. 67 and 68.

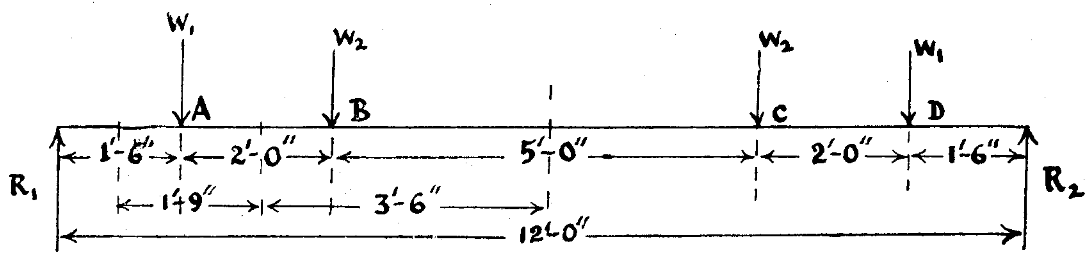


fig. 68.

The position of transom T_2 and the nature of loads on it is as shown in (Figs. 67 and 68).

The 6 tons knife-edge load which is on 10 feet traffic width of the bridge, comes on the transom T_2 of 12 feet (approx.) effective span [the actual length of transom will be about 20 feet as will be seen later in the design] through four roadbearers A, B, C and D.

First considering all loads except knife-edge load coming on transom T_2, we have (Fig. 68).

(*a*) Weight W_1 at Roadbearers A and D consisting of

(1) 76 lb. per sq. ft. of bridge surface [derived from 0·34 ton per linear foot of each traffic lane gives $\frac{0 \cdot 34 \times 2240}{10} = 76 \cdot 16$ lb./sq. feet] on width 1′ 9″ and length 5′ 0″ (Figs. 68 and 66) is $76 \times 1 \cdot 75 \times 5 = 665$ lb................a_1.

(2) Weight of portion of decking of area (1·75′ × 5′) and 4·5 inches thickness of decking is

$$1 \cdot 75 \times 5 \times \frac{4 \cdot 5}{12} \times \frac{60}{1} = 197 \text{ lb.}$$

Considering prolong duration of dead load we have twice 197 = 394 lb........a_2.

(3) Weight of roadbearer 'A', 5 feet long and of cross section 10″ × 5″ is

$$\frac{5}{1} \times \frac{10}{12} \times \frac{5}{12} \times \frac{60}{1} = 104 \text{ lb.}$$

Considering prolong duration of dead weight of material we have twice 104 = 208 lb. .... a_3.

(4) ∴ Total weight W_1 excluding knife-edge load $= a_1 + a_2 + a_3$
$= 665 + 394 + 208$
$= 1267$ lb.

(5) Considering 6 tons knife-edge load over 1′ 9″ length of transom (Fig. 68) is

$$\frac{6 \times 2240}{10} \times \frac{1 \cdot 75}{1} = 2352 \text{ lb.} \quad \ldots\ldots\ldots\ldots a_4.$$

(6) Net weight W_1 including knife-edge load is
$W_1 = 1193 + 2352 = 3545$ lb.

(*b*) Weight W_2 at roadbearers B and C consisting of

(1) 76 lb. per sq. ft. of bridge surface on width 3′ 6″ and length 5′ 0″ (Figs. 68 and 66) is
$76 \times 3 \cdot 5 \times 5 = 1330$ lb. (approx.) .... b_1.

(2) Weight of portion of decking of area (3′ 6″ × 5′ 0″) and 4·5 inches thickness of decking is

$$\frac{3 \cdot 5 \times 5}{1} \times \frac{4 \cdot 5}{12} \times \frac{60}{1} = 394 \text{ lb.}$$

Considering prolong duration of dead load we have twice 394 = 788 lb. .... b_2.

(3) Weight of roadbearer 'B', 5 feet long and of cross section 10″ × 5″ is

$$\frac{5}{1} \times \frac{10}{12} \times \frac{5}{12} \times \frac{60}{1} = 104 \text{ lb.}$$

Considering prolong duration of dead weight of material we have twice 104 = 208 lb. .... b_3.

(4) ∴ Total weight W_2 excluding knife-edge load $b_1 + b_2 + b_3$
$= 1330 + 788 + 208$
$= 2326$ lb.

(5) Considering 6 tons knife-edge load over 3′ 6″ length is

$$\frac{6 \times 2240}{10} \times \frac{3 \cdot 5}{1} = 4704 \text{ lb.} \quad \ldots\ldots\ldots\ldots b_4.$$

(6) Net weight W_2 including knife-edge load is
$W_2 = 4704 + 2326 = 7030$ lb.

(7) Thus complete system of loading on transom 'T_2' is as shown in Fig. 69.

(8) From Part III Figs. 26, 27 and 28 we have proved that
B.M. $= p_2 l_2 + p_1 l_1$, i.e., B.M. is same at points U and V.
In our case $p_1 = W_1 = 3545$ lb. ; $p_2 = W_2 = 7030$ lb.
$l_1 = 1' \, 6''$, $l_2 = 3' \, 6''$.

(9) $B.M._{max} = W_2 l_2 + W_1 l_1$
$= 7030 \times 3 \cdot 5 + 3545 \times 1 \cdot 5$
$= 24605 + 5318$
$= 29923$ ft. lb.
$= 29923 \times 12$ in. lb. $= 358076$ in. lb.

(10) Now $B.M._{max} = f\,Z$ and assuming width of transom to be 6″ we have

$$358076 = 2400 \times \frac{bd^2}{6}$$

$$\therefore d^2 = \frac{358076}{2400} \times \frac{6}{6} = 149$$

$$\therefore d = 13 \text{ inches (approx.)}$$

$\therefore$ Use transom 'T_1', 'T_2', etc., each of section 13″ × 6″.

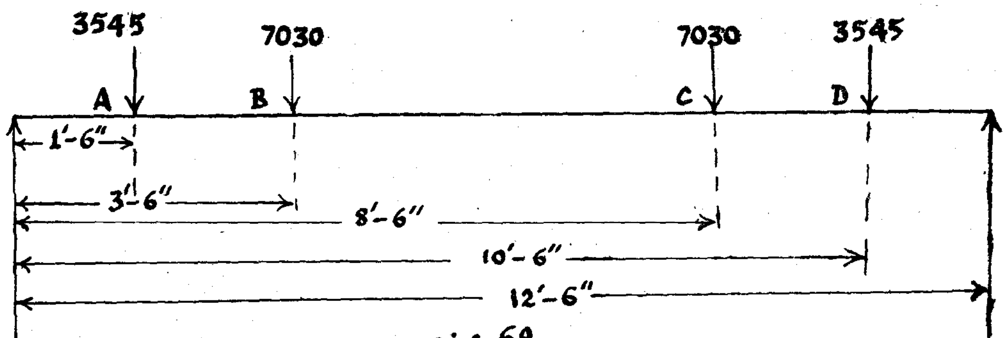


Fig. 69.

(F) To test Transom 'T_2' against Shear :—

(1) Loadings on transom 'T_2' as per previous calculations are

Due to a_1 ..	.. 665 lb.	not considering prolong duration.
,, ,, a_2 ..	.. 197 lb.	
,, ,, a_3 ..	.. 104 lb.	
,, ,, a_4 ..	.. 2352 lb.	
,, ,, b_1 ..	.. 1330 lb.	not considering prolong duration.
,, ,, b_2 ..	.. 394 lb.	
,, ,, b_3 ..	.. 104 lb.	
,, ,, b_4 ..	.. 4704 lb.	

$\therefore$ Total weight @ $W_1 + W_2 = 9850$ lb.

(2) $\therefore$ Max. shear $= R_1 = R_2 = 9850$ lb.

(3) Now $\frac{S_{max}}{A} = s_a$

$$\therefore s_a = \frac{9850}{13 \times 6} = 127 \text{ lb. per sq. in.}$$

(4) $s_m = \frac{3}{2} \times \frac{127}{1} = 191$ lb. per sq. in.

(5) Since 191 lb./sq. in. > the permissible max. shear of 180 lb./sq. in. for sal, the section 13″ × 6″ fails in shear.

(6) Try a section 14″ × 6″ for each transom

$$\therefore \; s_a = \frac{9850}{14 \times 6} = 116 \text{ lb./sq. in.}$$

$$\text{Now } s_m = \frac{3}{2} s_a = \frac{116}{1} \times \frac{3}{2} = 174 \text{ lb. per sq. in.}$$

This actual max. shear stress < the permissible shear stress for sal.

(7) ∴ Use transoms T_1, T_2, T_3, etc., each of section 14″ × 6″.

(G) To test Transom 'T_2' against Deflection :—

(1) Deflection is max. where B.M. is max.

∴ Max. deflection will occur at the centre of transom.

(2) Total load coming on transom through roadbearers is as shown in Fig. 70.

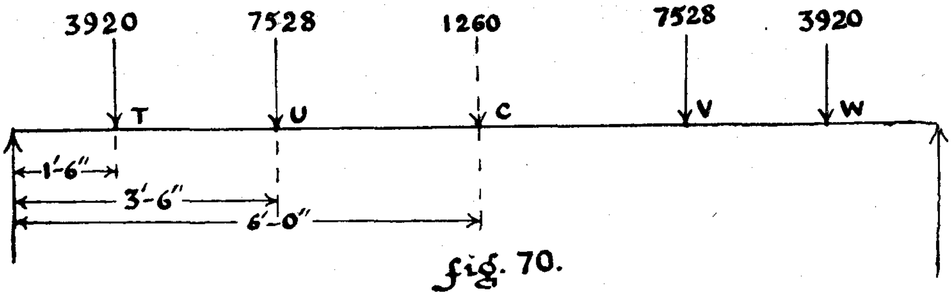


fig. 70.

transom T_2 loading for deflection

(3) To this loading is added deflection due to dead weight of transom acting as a concentrated load at centre 'C'.

(4) Thus load at T and W is

a_1 =	Once	×	665	=	665 lb.
a_2 =	3	×	197	=	591 lb.
a_3 =	3	×	104	=	312 lb.
a_4 =	Once	×	2352	=	2352 lb.
					3920 lb.

(5) Load at U and V is

b_1 =	Once	×	1330	=	1330 lb.
b_2 =	3	×	394	=	1182 lb.
b_3 =	3	×	104	=	312 lb.
b_4 =	Once	×	4704	=	4704 lb.
					7528 lb.

(6) Load at 'C' is $3\left(12 \times \frac{14}{12} \times \frac{6}{12} \times \frac{60}{1}\right) = 3 \times 420 = 1260$ lb.

(7) Now deflection at a point X due to a non-central load W (Refer Part III, Fig. 30) is given by

$$\delta_x = \frac{W \times a \times X}{EI\,(a + b)} \times \frac{b^2 + 2\,ab - X^2}{6}$$

(8) δ at centre 'C' of transom due to load 3920 lb. at T (Fig. 70) where

$a = 1{\cdot}5$ feet ; $b = 10{\cdot}5$ feet ; $X = 6$ feet.

$$\text{is } \delta_c = \frac{3920 \times 1{\cdot}5 \times 6}{EI\ (1{\cdot}5 + 10{\cdot}5)} \times \frac{(10{\cdot}5)^2 + 2 \times 10{\cdot}5 \times 1{\cdot}5 - (6)^2}{6}$$

$$= \frac{1}{EI} \times \frac{5880 \times 105{\cdot}75}{24}$$

(9) Again δ at centre 'C' of transom due to load 7528 lb. at 'U' (Fig. 70) where

$a = 3{\cdot}5$ feet ; $b = 8{\cdot}5$ feet ; $X = 6$ feet

$$\text{is } \delta_c = \frac{7528 \times 3{\cdot}5 \times 6}{EI\ (1{\cdot}5 + 10{\cdot}5)} \times \frac{(8{\cdot}5)^2 + 2 \times 8{\cdot}5 \times 3{\cdot}5 - (6)^2}{6}$$

$$= \frac{1}{EI} \times \frac{7528 \times 670{\cdot}25}{24}$$

(10) Again δ at centre 'C' of transom due to concentrated central load of 1260 lb. is

$$\delta_c = \frac{1}{48} \times \frac{WL^3}{EI} = \frac{1}{48\ EI} \times \frac{1260\ (12)^3}{1}$$

$$= \frac{1}{EI} \times \frac{1260 \times 36}{1}$$

(11) $\therefore$ Total deflection is that due to

twice [(8) + (9)] + (10) (twice because loads are systematical)

$$\therefore \text{ Total } \delta_c = 2 \left[\frac{1}{2\ EI} \left(\frac{5880 \times 105{\cdot}75}{6} + \frac{7528 \times 670{\cdot}25}{12} \right) \right]$$

$$+ \frac{1}{EI} \times \frac{1260 \times 36}{1}$$

$$= \frac{1}{EI}\ (103620 + 420390 + 45359)$$

Now 'E' for sal $= 2 \times 10^6$ lb. per sq. inch

$= 2 \times 10^6 \times 144$ lb. per sq. ft.

and 'I' for the section of transom 'T_2'$\cdot$14″ × 6″

$$\text{is } \frac{b \times d^3}{12} = \frac{6 \times (14)^3}{12} \text{ in.}^4$$

$$= \frac{6 \times (14)^3}{12 \times (12)^4} \text{ ft.}^4$$

$$\therefore \text{ Total } \delta_c = \frac{1}{2 \times 10^6 \times 144} \times \frac{12 \times (12)^4}{6 \times (14)^3} \times \frac{569369}{1}$$

$$= 0{\cdot}029 \text{ ft.}$$

Now max. allowable deflection $= \frac{1}{240}$th of the span

$$= \frac{1}{240} \times \frac{12}{1} = 0{\cdot}05 \text{ ft.}$$

$\therefore$ Actual total δ is less than max. allowable deflection.

Hence design of transom at T, T_1, T_2, etc., is safe against deflection.

(H) Design of Truss to span 40 feet Bridge :—

We will make use of two lattice girders 'through bridge' of the 'Howe Truss' design as shown in Fig. 71. In this truss, the top boom BH, the bottom boom aj, and the diagonals bC, cD, dE, fE, gF, hG, etc., are made of wood and the verticals bB, cC, dD, etc., are of iron

or steel bars. This type of truss is essentially suited to forest work as its applicability is indicated where timber is cheap, plentiful and transportation difficult.

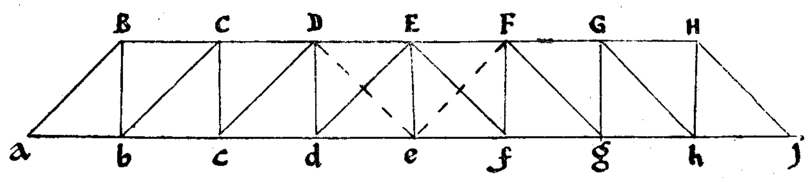


fig. 71.

In this truss ;

The diagonals take compression only
The verticals take tension only
The top boom takes compression only
The bottom boom takes tension only
} as will be seen later in the alternate design, Part V(c).

At present let the nature or forces in the above members be taken as correct. Three methods for the design of 40 feet span 'Howe through bridge' will be discussed in this and the following articles :—

The first is (a) Graphical method discussed in the present article Part V(a).
The second will be (b) Analytical method to be discussed in article Part V(b).
The third will be (c) Stress diagram method to be discussed in article Part V(c) along with
(d) Deflection of Howe Truss.

PART V(a).—GRAPHICAL METHOD

Introduction.—In this method close approximations have been taken to evolve several thumb rules to ensure quick yet safe design [the exact calculations will be given in analytical method Part V(b)].

Rules (1 to 5).—Simplified theory :

Rule (1).—The dead load on a truss (here a Howe Truss) due to decking, roadbearers, transoms and its own weight expressed in tons per foot run of span of truss is usually estimated by

(a) reference to previous experience with structures of similar type or

(b) may be calculated on assuming certain sizes for various members and readjusting the assumed weight after calculations of actual sizes of members if vide variance in assumed sizes of members occur. (See appendix I) or

(c) by empirical rules, e.g., in case of a timber truss, its dead weight can be arrived at from the following equation :

$$W = \frac{P}{750}\left(2L + \frac{L^2}{150}\right)$$

where W = Weight in tons of one truss. (See appendix I).
P = Live load in tons over L feet span of truss uniformly distributed on the truss.
L = Span of truss in feet.

(1) In our case live load equals :—

7 tons on one truss (due to 10 tons road roller, as will be explained below in Rule (2).

Therefore, in our case P = Twice $\times$ 7 tons (because 7 tons of point load = two $\times$ 7 tons of uniformly distributed load).

Note.—This is a safe approximation to convert a point load into an equivalent uniformly distributed load for purpose of calculations.

$$\therefore \ P = 14 \text{ tons.}$$

$$P = 14 \text{ tons} = 15 \text{ tons (say).}$$

$$L = 40 \text{ feet.}$$

$$\therefore \ W = \frac{15}{750}\left(2 \times 40 + \frac{40^2}{150}\right)$$

$$= \frac{15}{750} \times \frac{90 \cdot 66}{1} = 1 \cdot 8 \text{ tons (approx.)} = 2 \text{ tons (say).}$$

May it be noted that this empirical formula holds approx. true for timber trusses of depth $\frac{1}{8}$ to $\frac{1}{14}$ of the span.

(2) *Rule* (*2*).—The actual rolling load is replaced by an equivalent uniformly distributed load expressed in tons per foot run of span of truss for purposes of easy calculations and given by the following relation (Fig. 72). [For explanation of this relation refer Part V(*b*)]

$$w = \frac{2\ (W_1 + W_2)\ (L - x)}{L^2}$$

where w = equivalent uniformly distributed load in tons per foot run of span of truss.

W_1 = One axle load } case of a 10 tons road roller.
W_2 = Second axle load }

L = Span of truss in ft.

x = Distance of centre of gravity of road roller from W_1.

$x + y$ = centre to centre axle distances.

here $y > x$.

We are designing the truss to carry a 10 tons road roller passing one at a time over the bridge.

Normally if the road roller keeps to the centre of the bridge width, 5 tons load shall be borne by each Home truss.

But worst condition of loading shall arise when the road roller just scraps past one of the trusses (Figs. 58 and 59, Part IV as per approximate size of road roller) and Fig. 73 (as per actual standard dimension of road roller 10T).

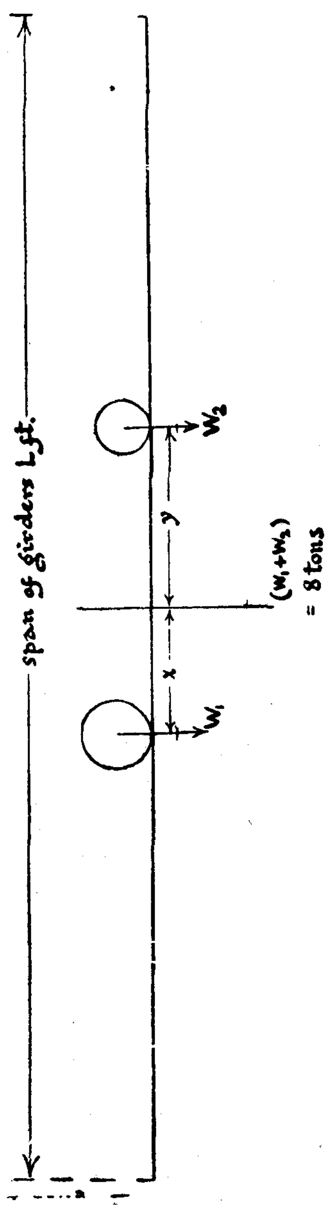
Hence the proportional live load on one truss is (Fig. 73)

$$R_1 \times 12 = 10 \times 8 \cdot 1$$

$$\therefore \ R_1 = \frac{10 \times 8 \cdot 1}{12}$$

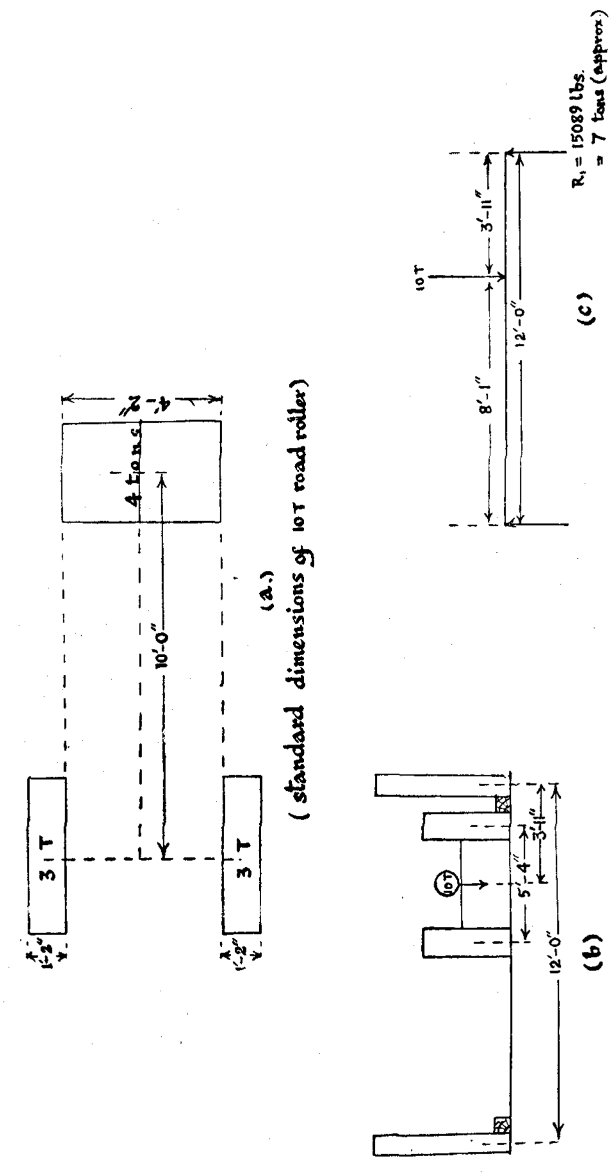
$$\therefore \ R_1 = 7 \text{ tons (approx.).}$$

(3) *Rule* (*3a*).—For truss of small span (say up to 80 feet) and depth we assume that both dead and live load to be carried entirely at the joints (node points) of the bottom boom from which the decking is suspended (Fig. 74).



span of girders L ft.
W1
W2
x
y
(W1+W2)
= 8 tons

Fig. 72.



4 tons
4'-2"
10'-0"
3 T
3 T
1'-2"
1'-2"
(a.)
(standard dimensions of 10T road roller)
10T
3'-11"
8'-1"
12'-0"
(c)
R1 = 15089 lbs.
= 7 tons (approx)
10T
5'-4"
3'-11"
12'-0"
(b)

Fig. 73.

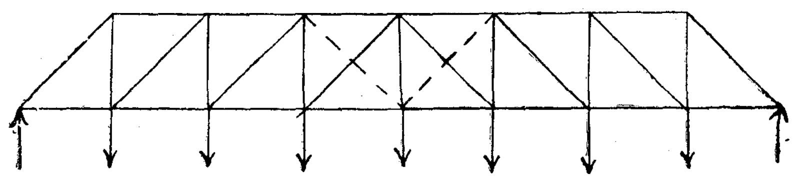


fig. 74.

Note.—In case of larger span of truss,

(i) dead load due to decking, roadbearers and transoms and also the live load should be taken as acting at joints of the bottom boom as in (3) but

(ii) dead load due to the weight of the material of the truss itself should be divided equally between joints of top and bottom booms (Fig. 75).

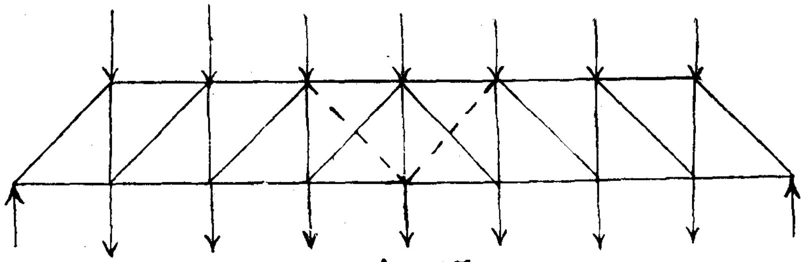


fig. 75.

Rule (*3b*).—A common method of distribution than Rule (3*a*) is to take,

(*a*) $\frac{1}{3}$ total dead load (including that due to wt. of truss) at joints of top boom,

(*b*) the remaining $\frac{2}{3}$ at joints of bottom boom,

(*c*) the live load of course always will be acting at the joints of,

(i) bottom boom in case of a 'through bridge'

and (ii) top boom in case of a 'deck bridge'.

(4) *Rule* (*4*).—The stresses in both booms will be a minimum under the action of dead load only and maximum when the whole truss is covered with live load in addition.

(5) *Rule* (*5*).—The diagrams of stresses in booms are first drawn as parabolas* with

(i) Max. ordinate $= \frac{WL}{8D}$ for dead load only

and (ii) $\frac{(W + w)L}{8D}$ when considering dead and live loads where

W = Total dead load over one truss over its complete span.
w = Total live load over whole truss over its complete span.
L = Span of the truss.
D = Depth of truss.

Para (5) above may be taken as correct at this stage but shall become more clear to the reader when the analytical method is explained.

* (1) The total dead and live load over the whole truss treated as a uniformly distributed load gives a parabolic curve for B.M.

(2) As B.M. is directly proportional to stress in a member, the diagram of stresses in booms shall be a stepped diagram with verticles lying on a parabolic curve (Fig. 76).

As, however, the truss is assumed to be loaded at joints only, the B.M. and, therefore, the stresses in booms will be constant throughout each bay ab, or bc, or cd, etc. (Fig. 71) and will be equal to the ordinate of parabolic diagram on the perpendicular let fall through the centre of that bay (Fig. 76). In this way the stepped diagrams in full lines are obtained for stresses in different chord members. As applied to our case of 40 feet span and I.R.C. 'B' class loading considering a 10 tons road roller, we get the diagrams as in Fig. 76.

(J) Explanation of Fig. 76 :—

(1) AB is the span drawn to scale (linear scale) of 1″ = 10′.
From the middle point 'g' on the ordinate downwards,
plot $\frac{WL}{8D} = \frac{(\text{twice } 14400) \times 40}{8 \times 5} = 28{,}800$ lb. to a scale (Force scale) of 15 tons = 1 inch, thus giving the point N.

[*Note.*—For B.M. computation, W, i.e., dead weight of truss is taken twice].

(2) Next a parabola* is drawn passing through A, B and with gN as the maximum ordinate.

(3) For load moving from right to left, ordinates let fall from nodes or joints k, j, h, etc., intersect at corresponding points k′, j′, h′, etc., on the parabola A N B. In the stepped diagram B to N the ordinates kk′, jj′, hh′ and gN give *minimum stress* (due to dead load only) in chords of bottom boom Bk, kj, jk and hg respectively.

(4) It can be shown mathematically [as in Part V(*b*) in later article] that the stresses (i.e., forces) in the chords of the bottom boom are equal to stresses (i.e., forces) in the corresponding chords of the top boom.
e.g. (Fig. 76)

Relation of

Bottom boom — Top boom

Stress in chord Bk	=	Stress in chord KJ
,, ,, ,, kj	=	,, ,, ,, JH
,, ,, ,, jh	=	,, ,, ,, HG

(5) Hence the left half of the diagram N′d (Fig. 76) gives the stresses (i.e., forces) in the chords of top boom for dead loads only.

(6) The paragraphs (1) to (5) above gave a stepped diagram dN′ and NB (Fig. 76) for stresses in chords of top and bottom booms respectively for dead load only.

---

* See Fig. 77.

(1) If M is the origin of co-ordinates, OMO′ being the 'X' axis and Mg the 'y' axis, the equation to the parabola is $x^2 = 4ay$.

(2) To find value of 'a' from eq. $x^2 = 4ay$ we have

$$a = \frac{x^2}{4y} = \frac{(\text{number of units of length in half span gB})^2}{4 \times \text{number of units of length in cM}}$$

This gives us the value of 'a' in numerical terms.

(3) Then for various known values of 'y' say $= gP_1$ or gP_2 values of 'x' can be calculated from eq. $x = \sqrt{4ay}$. These values of 'x' give positions of points x_1, x_2, etc., for corresponding values of y_1 ($= gP_2$), y_2 ($= gP_2$) etc.

(4) Joining these points the curve can be drawn and completed by symmetry on both sides of ordinate gM.

(5) Thus the parabola AMB is obtained.

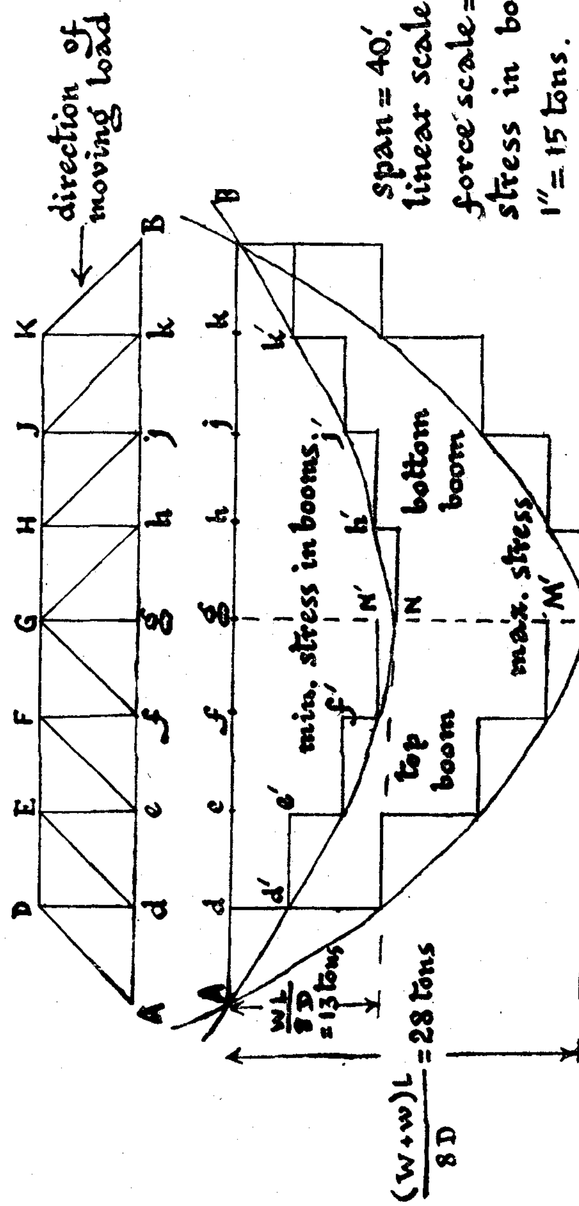

direction of moving load
span = 40'.
linear scale 1" = 10'.
force scale = stress in booms
1" = 15 tons.
min. stress in booms.
max. stress
top boom
bottom boom
$\frac{wL}{8D}$ = 13 tons
$\frac{(W+w)L}{8D}$ = 28 tons

fig. 76.

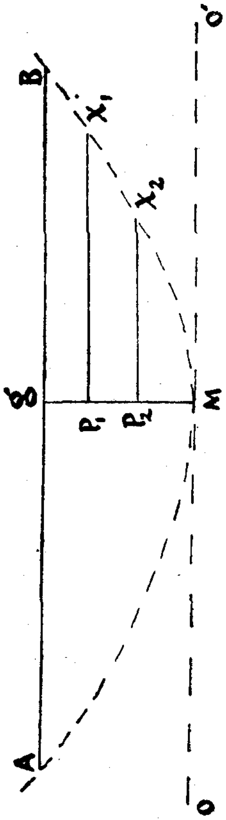


fig. 77.

In the same way, stepped diagram dM′ and MB can be drawn from parabola A M B, by

(i) drawing max. ordinate gM $= \frac{(W + w) L}{8D}$ for dead and live loads

$$= \frac{(13 + 15) 40}{8 \times 5}$$

$$= 28 \text{ tons.}$$

Rule (*6*).—This stepped diagram gives the *maximum* stresses in the various chords of the top and bottom booms for dead and live load combined (Fig. 76).

(K) Stresses (forces) in Diagonals or (bracing bars) :—

(1) The maximum stress in any bracing bar or diagonal, e.g., dE, eF, etc. (Fig. 76) will occur when the Shear Force is a maximum in that bay in which the diagonal is located because by bracing the chord members a truss is made stronger against deflection and bending. Thus the structure can only fail by shear. Hence a diagonal is designed with respect to max. shear in the corresponding bay (or panel).

(2) In drawing the Shear Force diagrams for the Howe truss (although not strictly in accordance to usual traditional rules for drawing S.F. diag.), it will be convenient to place (Fig. 78 stage I) the dead load on one side and the live load on the other side of the base line LL′ (representing span of truss) ;

(i) the dead load being drawn as a straight line TT′ [because dead load being uniformly distributed and all the time acting, gives as usual a triangular diagram (Fig. 78 stage I) for the shear force], and

(ii) live load as a parabola SL′ (shown chain dotted in Fig. 78 stage I) because the live load, in passing through the span, gives rise to a varying shear force, as the live load moves from one end to the other (also see appendix II)

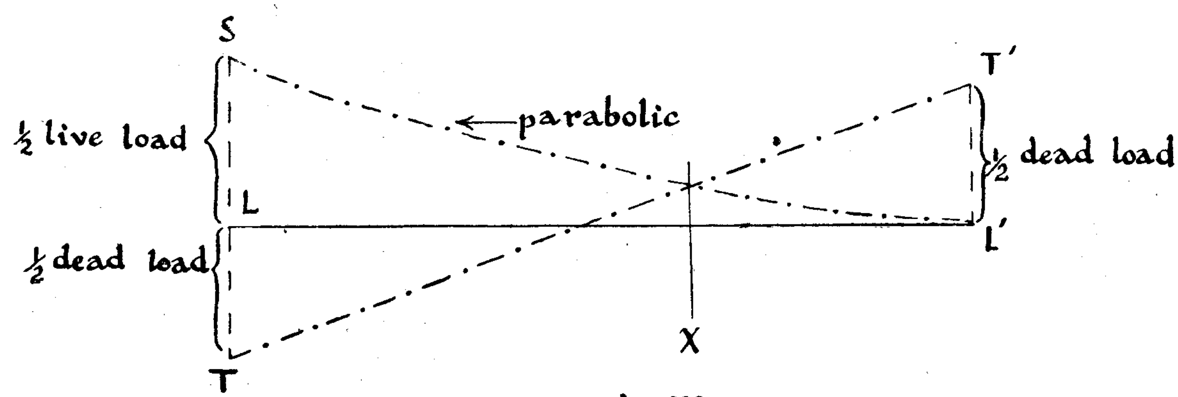


fig. 78.
(stage I)

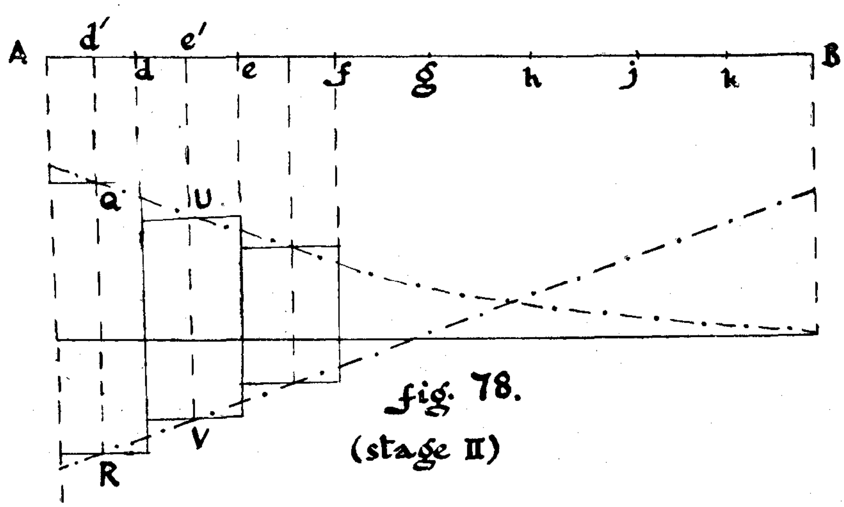


fig. 78.
(stage II)

(iii) but as shear force must be uniform over each bay (because between two successive joints or nodes, no further additional force or weight comes into play as per our assumption that all weights are assumed to act at the nodes only), the stepped diagrams shown in full lines* (Fig. 78 stage II) must be substituted in the same manner as for stresses (i.e., forces) in top and bottom booms (Fig. 76).

(iv) The completed stepped diagram of S.F. on the truss is as shown in Fig. 78 stage III for all bays and for dead and live load combined.

(3) *Rule* (*7*).—It is now only necessary to resolve the vertical S.F. aa′, bb′, cc′, etc. (Fig. 78 stage III) in respective bays Ad, de, ef, etc., along directions parallel to diagonal members AD, dE, eF, etc., as shown by aa″, bb″, cc″, etc., in Fig. 78 stage III to give max. stresses in diagonals corresponding to live and dead load both (because stress in any diagonal equals the resolved part of the vertical shear in that bay) or to put it in other words,

Rules (*8*) 'the stress in any vertical member, e.g., Dd, Ee, etc., Fig. 76 equals the shear ordinates, e.g., QR, UV, etc., in the bays Ad, de, etc., Fig. 78 stage II'.

(4) It will be seen that the stresses have a max. and minimum value for each diagonal (i.e., minimum with only dead load acting, e.g., 1–1, 2–2, etc., Fig. 79) and (max. when fully loaded, i.e., with dead plus live load, e.g., aa″, bb″, etc., Fig. 78 stage III).

(5) It is, however, important to note that minimum stresses in the diagonals do not in all cases occur under dead load only ; as from B to Z (Fig. 78 stage III), with the live load in certain position on the truss, a reduction of "the stress due to dead load" from the "stress due to live load" may actually occur due

---

* How to draw S.F. diag. for the truss :—(Fig. 78 stage II).

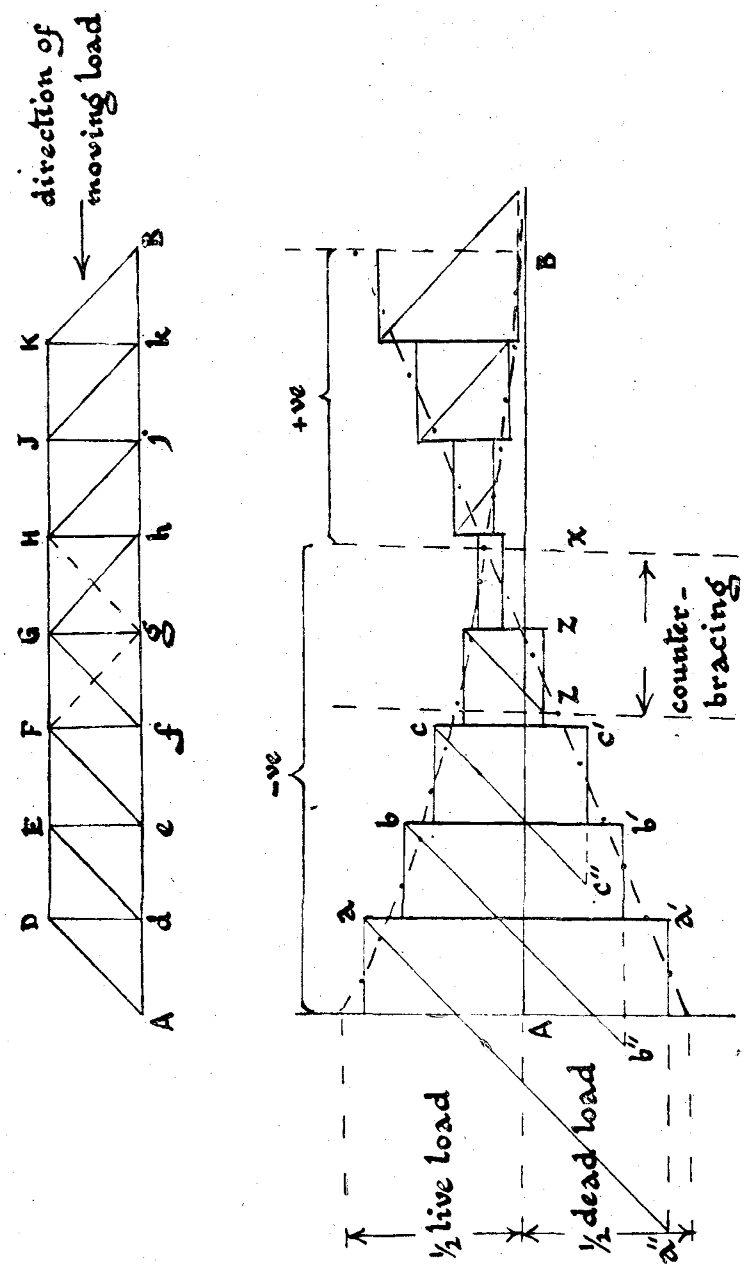
(1) Draw ordinates from the centre d′, b′, etc., of each bay Ad, de, etc., cutting both,

(i) the parabolic curve of S.F. due to live load and

(ii) the triangular straight line S.F. diag. due to dead load in points (Q, R), (U, V), etc., of the corresponding bays Ad, de, etc.

(2) Draw similar ordinates for every other bay.

(3) This gives the stepped diagram of S.F. for the truss (Fig. 78 stage III).



shear force scale 1" = 7·5 tons. Distance scale 1" = 10'.
fig. 78.
(stage III.)

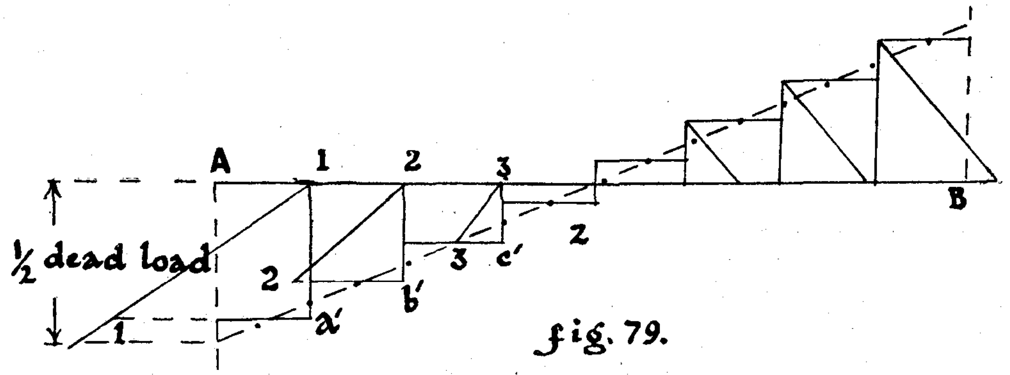


Fig. 79.

to opposite nature of S.F. ordinates for live and dead loads as in Fig. 78 stage III. (Note that in this Fig. from A to Z shear force diagram for dead and live load bear similar sign say negative whereas from Z to B the shear force diagram for dead and live load bear opposite sign, i.e., S.F. for live load still remains negative but S.F. for dead load becomes positive).

(6) In the same Fig. 78 stage III, it will be seen that the total value of the shear force changes sign at point X (from negative to positive because the positive dead load ordinate is greater than the negative live load ordinate of the S.F.) the point in which the S.F. diagrams for dead and live load intersect.

(7) (*a*) Thus when live load moves from right to left the total value of the combined shear forces (dead and live loads) is positive (i.e. +) from B to X, and negative (i.e. −) from X to A.

(*b*) It is obvious that with the live load moving in opposite direction, i.e., from left to right, another point X′ shall be found where the S.F. similarly changes sign. This point X′ will be at the distance from the centre of the span as point X was from Z (point Z being the centre of span Fig. 80) and thus total value of combined shear forces (dead and live loads) is

negative (i.e. −) from B to X′
and positive (i.e. +) from X′ to A } see Fig. 80.

(L) Counter-bracing :—

(1) *Rule (9)*.—If the live load shear in any panel is

(i) of opposite sign and also

(ii) greater than the dead load shear in the same panel (as shown from 'Z' to 'X' in Fig. 78 stage III) then a counter-bracing is required in-between panels from 'Z' to 'X'.

(2) This counter 'gH' (shown dotted Fig. 78 stage III) takes up the shear in that panel 'GHhg'. This shear places the diagonal 'Gh' (which was formerly designed for compression) now in tension, thus tending the points 'G' and 'h' to come closer, thereby the points 'H' and 'g' have a tendency to go apart. This tendency to go apart is checked by the counter-bracing 'gH' accounting for the tensile stress in the counter-brace.

(3) Also it is evident that if the dead load were very light compared to live load, i.e, ratio of live load to dead load is great, every panel except those at the extreme ends would be liable to a reverse shearing stress [as in para L(2) above] ;

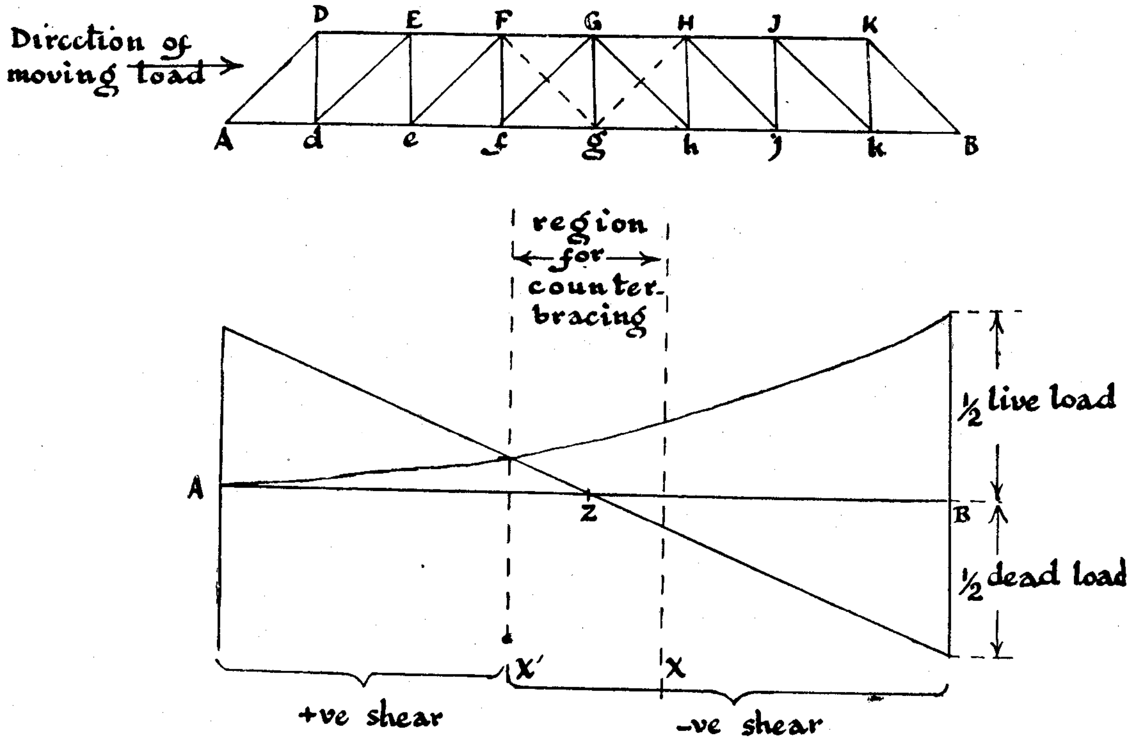


fig. 80.

thus the question whether a given panel requires to be counter-braced will therefore, depend upon the relative magnitude of the dead and live loads (see Fig. 81).

(4) The counter-bracing of a panel really makes the structure statically indeterminate because the actual stresses in the main diagonal of the counter-brace in a panel depend both upon

(i) their sections and

(ii) particularly on the initial conditions of attachment, i.e., fixing of these members.

The above conditions determine the initial stresses which may exist and which are really indeterminate.

Thus in calculations of the size of counter-brace, it is safer to assume that if the main diagonal carries completely the dead load stress (of compression only), then, when the final adjustment is made with the live load on the bridge, this live load—tending to reduce the dead load stress of compression in the diagonal—would put the counter-brace in complete tension without first reducing to stress (compression) in the main diagonal to a state of zero stress (i.e., neither compression nor tension, i.e., state of ease).

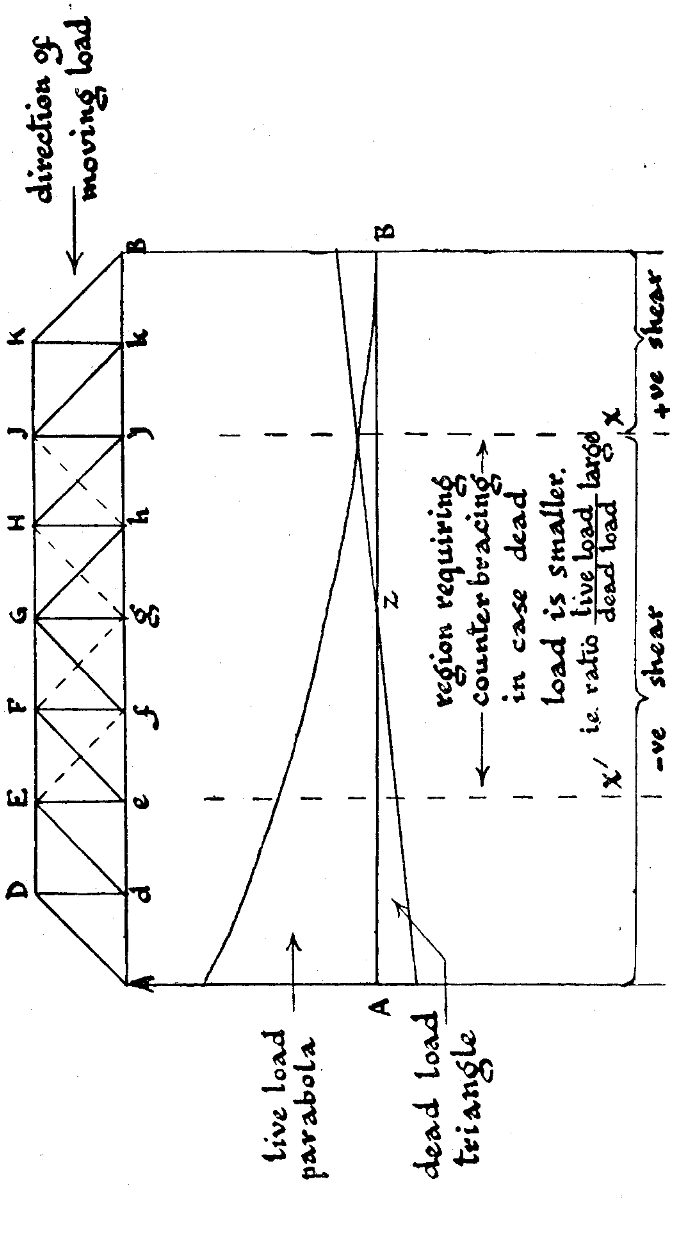

direction of moving load
D E F G H J K
A d e f g h j k B
live load parabola
dead load triangle
A Z B
region requiring counter bracing in case dead load is smaller, i.e. ratio live load/dead load large
x' x
-ve shear
+ve shear

fig. 81.

Thus the factor of ignorance is met with by designing the section of counter-brace of the same size as that of the diagonal in the panel requiring the counter-brace.

(M) Design of members of Howe Truss :—

From the previous calculations we have the following stresses in various members of the Howe truss. (Considering live and dead load combined) :—

Serial No.	Part of the truss	Member carrying max. stress	Amount of stress in Tons	Kind of stress	Reference Figs.
1	Bottom boom ..	Chord 'hg'	gM = 28	tensile	76
2	Topo boom ..	Chord FG	gM′ = 25	compressive	76
3	Verticals ..	Verticals	aa′ = 12	tensile	78 stage III
4	Diagonals ..	Diagonal	aa″ = 17	compressive	78 stage III
5	Counter-braces ..	Counter-brace 'gH'	aa″ = 17	tensile	Designed as other diagonals. Refer page 46 para (4).

(N) Design of bottom Boom :—

(1) Max. stress in the bottom boom as read from Fig. 76 is gM = 28 tons in the centre bays

$$\therefore \text{Section req.} = \frac{\text{Force (stress) in the member gM}}{\text{Intensity of stress for the timber used (i.e., sal)}}$$

$$= \frac{28 \times 2240}{2400} \text{ because extreme fibre stress for sal is 2400 lb./sq. in.}$$

$$= 26 \cdot 1 \text{ sq. inches.}$$

∴ Use bottom boom of section 6″ × 6″ throughout complete length AB (Fig. 82, p. 49). This section of 36 sq. in. allows for deductions in actual net section due to timber joints, etc., thus leaving a net effective section of 27 sq. in. approximately.

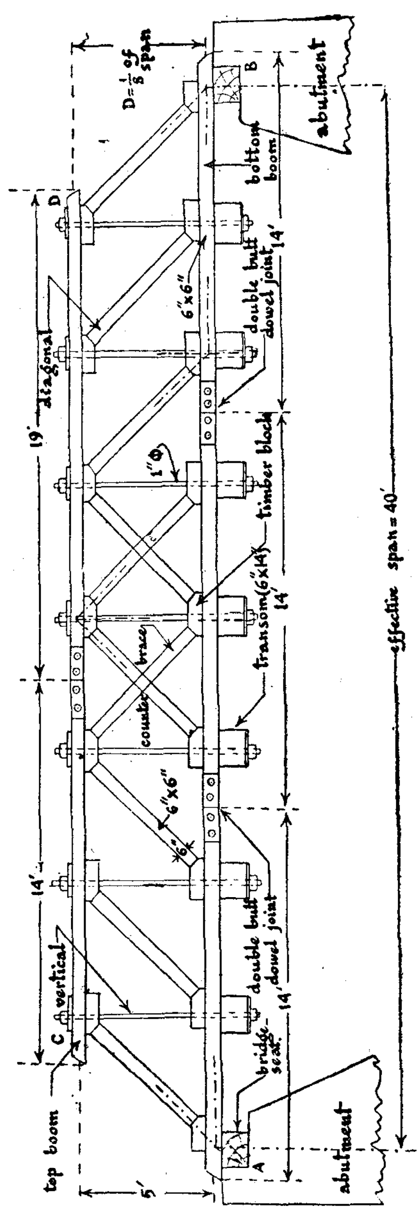
(*a*) Use one full length of bottom boom AB of 42 feet length (i.e., 40′ effective span plus 2 feet bearings) and of section 6″ × 6″ if such long lengths of timber are available.

(*b*) If long lengths are not available, break up the bottom boom in three parts (i.e., having two splicings). The splice is made with double disc dowels butt joint consisting of 8 disc dowels of timber Babul (*Acacia Arobica*) or Sissoo (*Dalbergia Sissoo*) size $4\frac{1}{2}''$ × $1\frac{1}{4}''$ and timber boards (i.e., equivalent of steel fish plates) of 3′ 6″ × 6″ × 6″ on either side of each splice (see Fig. 82), held by 4 nos. bolts $\frac{5''}{8}$ ϕ.

Note that :—

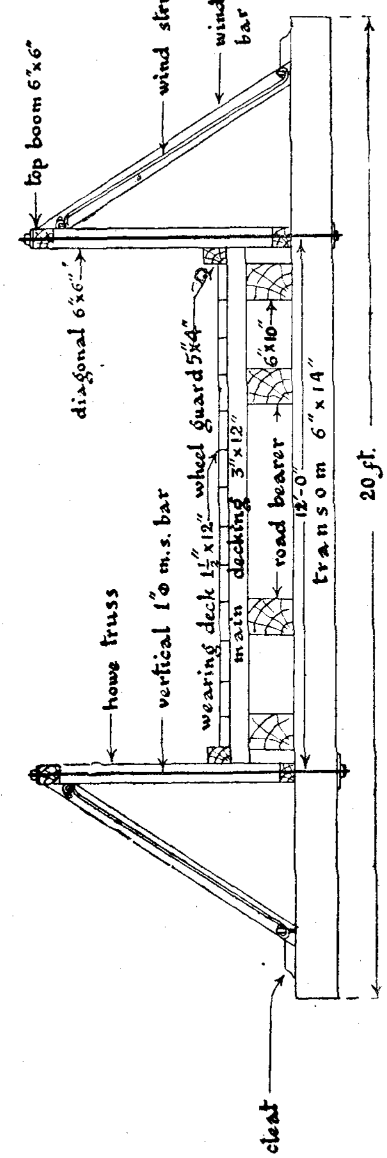
(i) the splice should not occur on a panel point (e.g., e, f, g, etc., Fig. 71).

(ii) and that it should be as far away from the centre of truss (i.e., panel point 'e' as possible Fig. 71).



top boom
C
vertical
14'
diagonal
19'
D
D = 1/8 of span
5'
A
B
abutment
abutment
bottom boom
bridge seat
double butt dowel joint
6"x6"
timber block
1"Φ
transom(6"x14")
brace
counter
14'
effective span = 40'

fig. 82.



top boom 6"x6"
wind strut 4"x4
wind tie steel bar 1/2"Φ.
diagonal 6"x6"
wheel guard 5"x4"
6"x10"
3"x12"
road bearer
12'-0"
transom 6"x14"
20 ft.
howe truss
vertical 1"Φ m.s. bar
wearing deck 1½"x12"
main decking
cleat

fig. 83.

(3) In absence of long lengths, the top boom is also spliced as shown in Figs. 82 ; 84 ; & 85.

(P) Design of top Boom :—

(1) From the statement on page 48 para M(1) and Fig. 76, max. stress is in the chord FG of the top boom and = 25 tons.

(2) For practical purposes we design the top chord to take the max. stress of the bottom chord, i.e., for stress = 28 tons.

(3) ∴ Use top boom of section 6″ × 6″ throughout length CD. This section of 36 sq. in. allows for deductions in actual net section due to timber joints, etc. (Figs. 82 & 83).

Note.—(i) Either use top boom CD of one complete lengths 33′ if available or (ii) if long lengths are not available break up the top boom in two lengths of 14′ and 19′ (i.e., having one splice) as in Fig. 82. The detail of joint is same as that in bottom boom (Figs. 84 & 85).

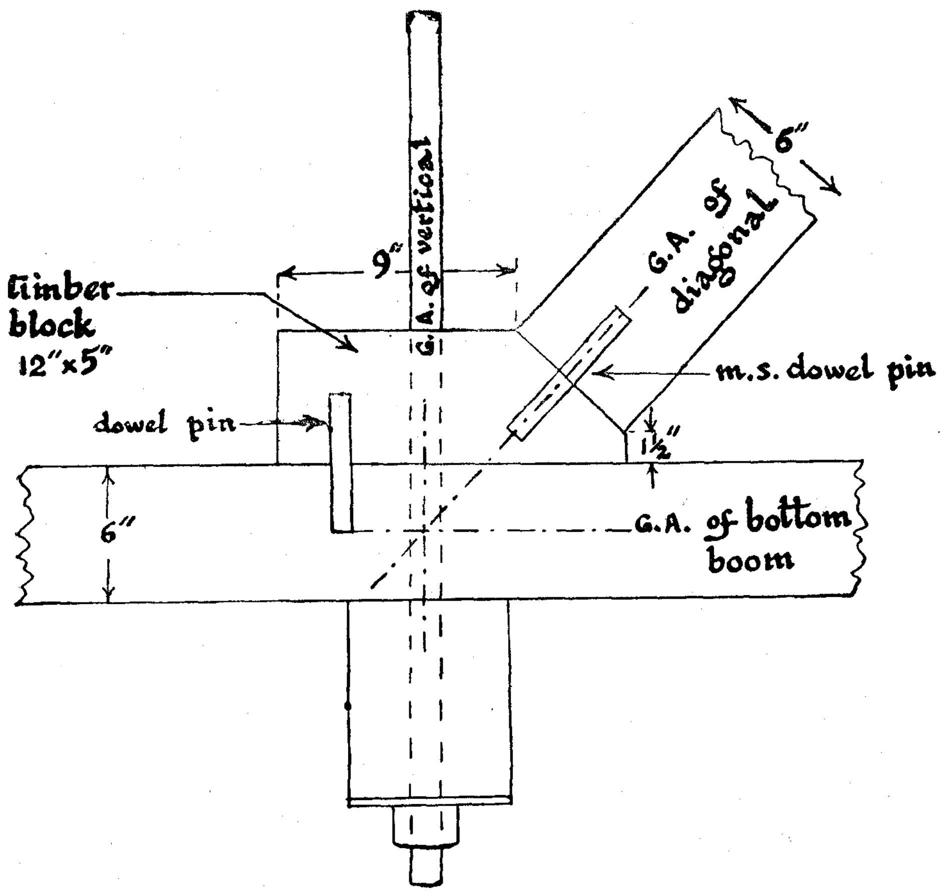


Fig. 84.

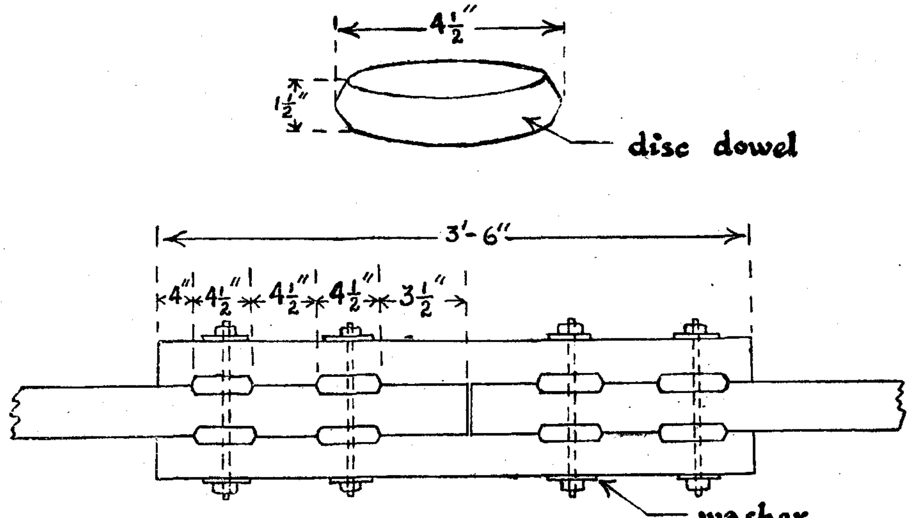


fig. 85.

Q) Design of Diagonals :—

(1) From the statement on page 48 para M(1) and Fig. 78 stage III, max. compressive stress is in the diagonal AD (or KB) and = aa″ = 17 tons.

(2) $\therefore$ Design it as a column (Refer previous remarks on design of timbers columns in Part IV).

(3) Consider a section of column 6″ × 5″

$\therefore$ slenderness ratio $\frac{l}{d} = \frac{7 \times 12}{5} = 17$

where l = AD $5\sqrt{2}$ = 7 feet approx. = 84 inches

and d = 5 inches.

Since $\frac{l}{d} > 15$ design the member as a long column.

(4) Permissible value of compressive stress $f_p = f_e \left(1 - \frac{l}{60d}\right)$

$$= 1700 \left(1 - \frac{84}{60 \times 5}\right)$$
$$= 1224 \text{ lb./sq. in.}$$

(5) Now area of section $= \frac{\text{Force}}{f_p} = \frac{17 \times 2240}{1224}$

$= 31 \cdot 111$ sq. in.

(6) Use an overall section of 6″ × 6″ which allows for reduction of joints, etc. (Fig. 82).

(R) Design of Counter-braces :—

(1) This will be designed as other diagonals. [Refer para (Q)].

(2) $\therefore$ Use a section of 6″ × 6″ for counter-braces (Fig. 82).

Note.—(1) So far we have designed members of Howe truss such that as a whole, the truss will not fail,

(*a*) against Bending,

(*b*) against Shear.

(2) We do not know as yet the behaviour of this truss (considering the sizes of its various members as designed so far).

(c) Against Deflection, i.e., whether the sizes of various members arrived at, will give to the truss such stiffness as not to deflect the truss, above its limit of $\frac{1}{240}$th span.

(3) Until the sizes of various members of the truss are safe to give Deflection results within the permissible limit (i.e., $\frac{1}{240}$th of span), we cannot summarize the sizes of members of Howe truss in tabular form.

(4) Consideration of Deflection of Howe truss will be treated in Part V(c).*

APPENDIX I

Referring to our case of 40 feet span Howe bridge, the dead load of material of the bridge is calculated as under [according to page 36, para H(1)(b)] :—

(i) For dead weight of one Howe truss : (timber sal)

Serial No.	Member	Assumed section size	Wt. per cu. ft.	Dead load of members	No. required	Total Dead load	REMARKS
		in × in	lb.	lb.	No.	lb.	
1	Booms ..	8 × 12	60	$\frac{8}{12}\times\frac{12}{12}\times\frac{42}{1}\times 60 = 1600$	2	3200	Span = 40′+2=42′ Depth = 5′
2	Diagonals (each of length 5/2 =7 feet approx.).	6 × 6 (Diagonals taken at 45° to the booms).	60	$\frac{6}{12}\times\frac{6}{12}\times\frac{7}{1}\times\frac{60}{1}$	8+2	1050	10 diagonals comprises of 8 diagonals for the truss and 2 as possible counter braces.
3	Verticals ..	Steel rod $1\frac{1}{4}''$ ϕ	400	$\left(\frac{5}{4\times 12\times 12}\right)^2\times 3\cdot 14\times 5 \times 400 = 17\cdot 5$	7	122·5	
				Total dead load of one truss	=	4372·5 lb.	
					=	2 Tons (approx.)	Compare this result of 2 Tons with the results of the empirical rule on page 36 para H (1)c which gives 1·8 tons = 2 Tons (approx.).

* Separate copies of this article can be obtained from the Publicity and Liaison Officer, Forest Research Institute and Colleges, Dehra Dun on payment.

(ii) For dead weight of superstructure of Bridge calculated from previous exact calculations :—

Serial No.	Member	Assumed section size	Wt. per cu. ft.	Dead load of members	No. required	Total Dead load	REMARKS
		in × in	lb.	lb.	No.	lb.	
4	Transoms ..	14 × 6	60	$\frac{14}{12} \times \frac{6}{12} \times 20 \times 60 = 700$	7	4900	20′ length of transom.
5	Roadbearers ..	10 × 15	60	$\frac{10}{12} \times \frac{5}{12} \times 40 \times 60 = 833$	2	1660	Out of 4 R.B. weight of two are taken by each truss.
6	Decking ..	..	..	..	..	2400	Wt. of 80 cu. ft. of decking = 2400 lb. ref. Pt. II table I.
7	Bridge Seats ..	8 × 4	60	$\frac{8}{12} \times \frac{4}{12} \times 13 \times 60 = 174$	2	348	
8	Inclined struts for wind Bracing Howe truss with transom	4 × 4	60	$\frac{4}{12} \times \frac{4}{12} \times 7 \times 60 = 47$	14	658	Two struts for each transom.

Total dead load = 14338·5 lb.
= 14400 lb. (approx.).
Total dead load considering one truss = 10000 lb.

NOTE :—(*a*) For calculations of B.M., dead load = twice 10000
= 20000 lb. = 9 Tons (Approx.).

(*b*) For calculations of Deflection, dead load = thrice 10000 lb.
= 30000 lb. = 14 Tons (Approx.).

(*c*) For calculations of B.M. shear and deflection of one Howe Truss we take into account

(*i*) Dead load due to half the superstructure coming over one truss,

(*ii*) Dead load of one truss only.

Thus for calculation of B.M. Dead load over one truss = 9 Tons and for calculation of Deflection Dead load over one truss = 13 tons.

APPENDIX II

[Refer page 42, para K(2)(ii), Part V(*a*)]

Shear diag. for uniformly distributed moving Loads :—

In our case the 10 tons road roller (the moving load) has been replaced by an equivalent uniformly distributed load of 'w' tons per ft. run of span of truss by the

$$\text{eq. } w = \frac{2 (W_1 + W_2) (L - x)}{L^2}$$

[reference page 36, simplified theory, para H(2)].

(1) Let the beam (Fig. 1) be loaded with a uniformly distributed load of 'p' lb. per linear foot of span which can be moved on or off the beam (truss in our case).

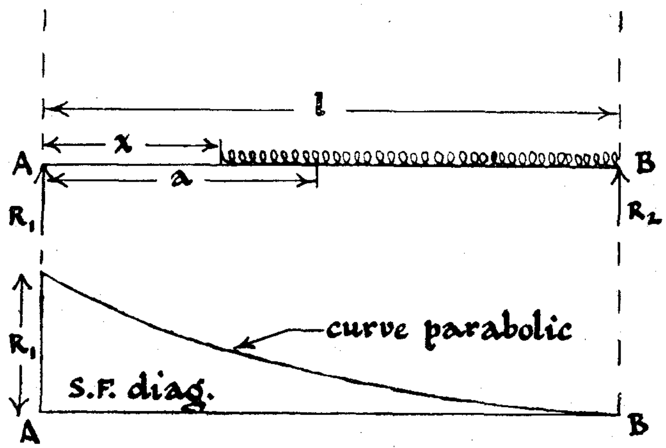


fig. 1. (appendix II)

(2) The left reaction R_1, when the end of the moving load is at a distance 'x' from left reaction will be given by

$$R_1 \times l = (l - x) p \times \frac{l - x}{2} \text{......(by taking moments about } R_2 \text{)}$$

$$\therefore \quad R_1 = \frac{(l - x)^2}{2l} p.$$

(3) The shear at a point at distance 'a' from the left reaction will be

$$S = R_1 - (a - x) p$$

$$= \frac{(l - x)^2}{2l} p - (a - x) p \qquad \text{(By substituting value of } R_1 \text{)}$$

$$= \frac{p}{2l} [l^2 + x^2 - 2xl - 2la + x \times 2l]$$

$$\therefore \; S = \frac{p}{2l} x^2 + \frac{p}{2} (l - 2a).$$

The above equation is that of a Parabola because S (the one variable) varies as the square of the other variable 'x'.

(*continued*)

THE HIMALAYAN CONIFERS II*

The ecology of humus in conifer forests of the Kulu Himalayas†

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In a review in *Current Science* (1936, p. 89) of the admirable work on Kulu forest soils by Taylor, Mahendru, Mehta and Hoon (1936) it was pointed out that "the chemical analysis of the primary rocks from which the soils are derived, for example, would lead to a better appreciation of its weathering to the present profiles",—and "the C/N ratios of A_0 and A_I profiles might have yielded valuable indications of the nature of the humus".

Since then Hoon and Dhawan (1941)‡ have published interesting accounts of C/N ratios of soil profiles from conifer forests of the Kulu and Kashmir hill areas. However, a complete ecological study of the humus, its relationship to forest growth on the one hand and to physical and structural geology on the other was still needed. Such information is indispensible to foresters desiring regeneration of conifer species and in correct manipulation of crop for obtaining results of better economic value. The present work was, therefore, undertaken in the Kulu Himalayas at the invitation of the Conservator of Forests, Northern Circle, Punjab, in the summers of 1948 and 1949. Detailed relationship between forest communities and main geological features of the region have already been given (Puri, 1949, 1950 a, b) and ecology of the humus and relationship of forest communities with the soil complex will now be examined.

Samples of rock, soil and plant were collected by one of us (G.S.P.) and analysis were made by the following methods :—

1. Total and exchangeable calcium were determined by the usual oxalate method (Loomis and Shull, 1936) followed in earlier work (Puri and Gupta, 1950).
2. pH was determined electrometrically in suspension of 1 : 5 air dry soil and distilled water, with glass electrode, using Beckman dry battery pH meter.
3. Nitrogen was estimated by macro kjeldahl's method.
4. Carbon in leaves was got by substracting ash + N from 100 and dividing it by 1·95 as was suggested by Waksman (1938) for fresh leaf-litter.
5. Loss on ignition was determined by igniting oven dry soil to constant weight on bunsen burners, and this was taken equivalent to organic matter of the soils as was done by Taylor, *et. al.* (1936) and Hoon and Dhawan (*loc. cit.*) in their investigations of Kulu and Kashmir soils.
6. Foliar ash was determined by igniting oven dry leaf material to constant weight in electric muffle furnace at 800°C.

For soil analysis we have been freely helped by Dr. R. S. Gupta, Soil Chemist, to whom we are grateful for willing co-operation. Field assistant Lakhmi Chand rendered invaluable service on the second tour. D.F.O. Kulu, D.F.O. Working Plans, Attached Officers to these divisions and their assistants gave ungrudging help in field work and G.S.P. wishes to record his best thanks to all those. He is also thankful to the Director, Geological Survey of India, Calcutta for identifying some rock samples and confirming the identification of others at his request. To Mr. C. R. Ranganathan, President, F.R.I. ; and to Dr. R. C. Hoon, who kindly went through this paper, we are grateful for their suggestions. Statistical analyses of the data were done by Dr. K. R. Nair, to whom we offer our best thanks.

* No. I appeared in this Journal April 1950 issue.
† Contribution from the Ecology section of Silviculture Branch.
‡ For references to literature please see Feb. 1951 issue in which part II of this paper will be published.

The main rock types in the area studied are given in table I, together with lithological composition of the rocks, their CaO content, location and the type of forest communities occurring on them.

It will be seen that of all the rocks studied quartzite contains the least amount of CaO and the only other rocks that compare with it in this respect are mica schist from Nagar and Carbon phyllite from Jari and Nagar. These latter rocks contain large amounts of quartz and usually bear the chir pine and/or the blue pine communities. Biotite schist and mica schist from another locality at Nagar contain appreciable quantities of CaO and here blue pine-deodar, deodar and spruce communities were found. Of the rocks studied the highest amount of CaO was found in phyllite from Jari, Kasol and Nagar and in biotite gneiss from Monali, on which deodar and spruce communities were usually found. Thus, there appears to be a general correlation between CaO in rocks and forest communities in the areas studied. The availability of CaO at different places in a single bed depends upon its structure ; and relationship between the distribution of forest communities with respect to structural and physical features of rocks has been described in an earlier paper (Puri, *loc. cit.*).

TABLE I

Locality	Rock	Composition	Geological slope	Aspect	% CaO*	Forest Community
Nishala Nala, Nagar	*Carbon phyllite*	Quartz, biotite, muscovite chlorite and carbonaceous matter.	Dip	NE.	0·35	Blue pine.
Jari	*Carbon phyllite*	Quartz, mica and carbonaceous matter.	Dip	NE.	0·41	Blue pine—Chir pine.
Jari	*Quartzite*	Quartz	Scarp	all	0·44	Chir pine.
Kasol	*Quartzite*	Quartz	Scarp	all	0·45	Chir pine.
Kasol	*Quartz-sericite schist*	Predominantly composed of quartz with altered mica.	Dip	NE.	0·45	Chir pine—Blue pine.
Nishala Nala, Nagar	*Mica schist*	Muscovite, chlorite and biotite with iron ore and quartz.	..	N.	0·40	Blue pine.
Nagar	*Mica schist*	Muscovite, chlorite and biotite with iron ore and quartz.	..	N.	0·50	Blue pine—deodar.
Nagar	*Mica schist*	Muscovite, chlorite and biotite with iron ore and quartz.	..	S.	0·61	Blue pine—deodar.
Monalsukhad, Monali	*Pegmatite*	In contact with muscovite, gneiss composed of quartz, feldspar with muscovite mica.	Scarp	S.	0·60	Blue pine.
Monali	*Biotite schist*	Quartz, feldspar, biotite and muscovite with tourmaline, apatite and iron ore.	Dip	N.	1·13	Deodar and spruce.
Nishala Nala, Nagar	*Chlorite phyllite*	Chlorite, quartz, Muscovite and iron ore.	Dip	..	1·02	Deodar.
Nishala Nala, Nagar	*Phyllite*	Quartz, muscovite, chlorite, biotite and iron ore.	Dip	..	1·28	Deodar.
Jari, Kasol	*Phyllite*	Chlorite, mica and quartz.	Dip	N. & S.	1·47	Deodar.
Monalsukhad, Monali	*Biotite gneiss*	Quartz, plagioclase, biotite, muscovite, chlorite with apatite.	Dip	..	1·80	Deodar and spruce.

* Average of two determinations.

The rock types studied differ considerably in their weathering properties which account for differences in geomorphological features in different valleys. Thus, quartzite and schists which are two of the hardest rocks in this area form spurs ; and phyllite and sandstones weather easily forming deep depressions and gullies, in which soils are usually deep and moist ; skeletal and shallow soils occur in the former rock areas.

In addition to the rock types and soils occurring in *situ*, a great majority of the soils in the valleys are secondary, being either river alluvia or morainic outwash. Their composition is very varied and shows the presence in some places of unweathered blocks of hard rock in a matrix of finely weathered phyllite or sandstone. Most of the soil samples to be described in this paper were gathered from these re-assorted deposits which being derived from heterogenous rock materials do not show any special relationship with any one type of rock, excepting in one or two cases where the silver sand from quartzite or black clay from phyllite rocks affected the nature of the soils more prominently.

The soil profiles studied by us are fundamentally allied to those described by Taylor and his co-workers (*loc. cit.*) from this area, and correspond to podsolized, brown earth and skeletal types. The morphological features of the profile are, therefore, not given here, for which the reader is invited to consult the above cited work. Most of the soil profiles under deodar and blue pine communities and especially those on sandy alluvia, with boulders close to the surface show podsolic features with base saturated and less acidic A_0 and A_I horizons, which correspond to 0″–3″ top-soil and the layer next below that, respectively, in soil profiles studied by us. In these profiles B layer of black colour and rich in humus was found at depths of 12–36 inches. The profiles on phyllite rock did not show podsolic features ; and in those under kail on silver sand derived from quartzite rock horizons were more clearly marked ; reminding in one or two cases acidic podsol profiles on Bagshot Sands in Heathy country of Southern England. Soil profiles under the chir pine community were mostly skeletal, being found on scree cones that are topographically immature and unstable habitats. In one case on sandy substratum profile under chir pine showed faint podzolization but the crop here contained a good many poles of the blue pine. Skeletal and only weakly podolized profiles have been recorded under the chir pine community by Taylor, *et. al.* (*loc. cit.*). Under spruce and silver fir communities at higher levels, on glacial morains, soil horizons were again ill-defined, and profiles corresponded mainly to Brown earth types.

CHEMICAL CHARACTERISTICS OF THE HUMUS

The complete data for pH, loss on ignition (or organic matter content), Ca content and nitrogen in soil profiles under various forest communities are given in appendix*, and summary of these is presented separately for the top layer in Table II and average of all the other layers of the soil profiles in Table III.

On the basis of the soil properties studied the conifer soils of this region tend to fall in three distinct soil types and these bear characteristic forest communities :—

1. *Skeletal soils* derived mostly from block screes of quartzite, schist or phyllite, or newly laid alluvia, with high pH values, low amounts of nitrogen, low organic matter content, medium amounts of CaO in the surface layers support chir pine community. These soils occur at lower altitudes below 5,500 feet in the valley and are topographically unstable and least leached.
2. *Podsolized or old Brown earth soils* derived from older alluvia or flood-plain deposits, with medium pH value, medium amounts of nitrogen, medium organic matter

* Appendix is given in part II of this paper to be published in Feb. 1951 issue.

content and least amount of soil calcium bear the blue pine, blue pine-deodar and deodar communities, at intermediate altitudes of 5,000–8,000 feet. These soils are stabilized and show clearly developed A and B horizons. These are highly leached and those with boulders in lower layers and sandy in composition sometimes show humus pan in B horizon.

3. *Brown earth soils* derived from high-level flood-plain deposits, or/and glacial morains which form deep clayey soils without boulders, with lowest pH, high amounts of nitrogen and organic matter, and high amounts of calcium in the surface layers support spruce, spruce-silver-fir communities. These occur at high altitudes above 8,500 feet and show poor characterization of distinct zones.

The statistical analysis of the data for the top layer only for each soil type and for each forest community within each soil profile type is given in Table II. There are statistically significant differences in the mean values of each character between the soils of Brown earth and podsol types. Despite the fact that in the skeletal soils the mean values are based on only two observations and are, therefore, subject to much larger standard errors than the corresponding mean values in the other two types the former mean values have turned out to be significantly different from the mean values in Brown earth type for pH, loss on ignition and nitrogen. In the case of the Ca the mean value in skeletal soils is not significantly different from the mean values in either of the two types of soil profiles.

Interesting and significant differences between the soil properties and altitude were also seen. Thus the data indicate that the higher the altitude the lesser the pH and greater the organic matter and nitrogen of the soils. The increase in altitudes is generally accompanied by lowering of temperature and in these hills it follows an increase in rainfall and precipitation. Thus, the relationship shown between altitude and soil properties may also hold good for rainfall and temperature. Our results agree closely with those of Hoon and Dhawan (*loc. cit.*) and Jenny's (1930) work in the United States, who has shown interesting relationships between soil nitrogen and P/E ratio at various stations.

The decrease in pH and increase in organic matter content of the soils with increase in altitude was shown by the data of the author (Puri, 1948, 1948 a, 1949 a, 1950 c) and those of Pearsall (1932) and Salisbury (1922) in some English forests and those of several continental workers and it may be concluded that this is a general principle in soil development.

A point of considerable interest to which Taylor and others (*loc. cit.*) and Hoon and Dhawan (*loc. cit.*) have already made pointed reference is that these Kulu soils differ from soils of the European and American forests in not being base deficient in A_0 and A_I horizons. With an increase in altitude in the Kulu Himalayas there is no corresponding decrease in Ca content in the surface layers of the soil which is usually the case in soils of the northern latitudes. This may be due to the greater amounts of Ca in the moraines and flood-plain deposits themselves or due to differences in climate, but we are unable to explain this fully at present.

TABLE II

TABLE II.—*Values of Mean + SE. of constituents of the humus* (Based on top layer only)

Community	Characters: Altitude above sea-level	Characters: No. of profiles	pH: Mean for each community	pH: Mean±SE. for each soil type	% Loss on ignition: Mean for each community	% Loss on ignition: Mean±SE. for each soil type	Ca in millequivalent: Mean for each community	Ca in millequivalent: Mean±SE. for each soil type	% Nitrogen: Mean for each community	% Nitrogen: Mean±SE. for each soil type	Soil profile type
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	ft.										
Chir pine ..	4000–5000	2	6·90	6·90±0·275	17·35	17·35±9·20	40·80	40·80±12·85	0·425	0·425±0·1719	Skeletal. I.
Deodar ..	5000–7500	17	6·43		23·34		40·08		0·451		Podsolized and sometimes brown earth type. II.
Blue pine ..	4500–7000	5	6·56	6·45±0·078	26·74	23·79±2·60	33·72	38·68±3·63	0·518	0·454±0·0486	
Deodar—Blue pine ..	6000	3	6·37		21·43		39·07		0·363		
Spruce ..	8500	4	5·85	5·88±0·123	25·70	38·15±4·11	48·30	62·71±5·75	0·710	0·785±0·0769	Brown earth type. III.
Silver fir ..	9000	6	5·90		46·45		72·32		0·835		
Significance of diff. between soil profile types			†		*		†		†		
Bar diagram			I II III		III II I		III I II		III II I		

* Indicates significance at 5% level of probability. † Indicates significance at 1% level of probability.

TABLE III

TABLE III.—*Values of Mean + SE. of constituents of the humus* (Based on average of all the layer excluding top layer)

Community	Characters: Altitude above sea-level	Characters: No. of profiles	pH: Mean for each community	pH: Mean±SE. for each soil type	% Loss on ignition: Mean for each community	% Loss on ignition: Mean±SE. for each soil type	Ca in millequivalent: Mean for each community	Ca in millequivalent: Mean±SE. for each soil type	Soil profile type
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ft.								
Chir pine ..	4000–5000	2	6·60	6·60±0·245	3·70	3·70±1·799	20·75	20·75±6·758	Skeletal. I.
Deodar ..	5000–7500	17	6·15		6·02		21·41		Podsolized and sometimes brown earth type. II.
Blue pine ..	4500–7000	5	6·34	6·21±0·069	3·20	5·38±0·509	10·30	18·41±1·912	
Deodar—Blue pine ..	6000	3	6·33		5·43		14·90		
Spruce ..	8500	4	5·70	5·63±0·110	5·35	7·23±0·804	30·60	26·86±3·022	Brown earth type. III.
Silver fir ..	9000	6	5·58		8·48		24·37		
Significance of difference between soil profile types				*		N.S.		N.S.	
Bar diagram				I II III					

NOTE :—N.S. means not significant at 5% level of probability. * Indicates significance at 1% level of probability.

A very interesting relationship between pH of the soil and forest communities is seen in Table IV below :—

TABLE IV

pH Class	−6·00	6·10–6·50	6·51–6·80	6·81–7·00	7·10–7·50	7·51–8·00	Total No. of soils studied for each community
			Number of soils for each pH class				
Spruce community ..	14	5	..	..	..	..	19
Silver fir community ..	23	3	1	..	..	..	27
Blue pine community ..	2	12	5	3	..	..	22
Deodar community ..	24	37	13	3	1	1	79
Chir pine community ..	..	8	8	2	5	..	23

The table also shows at a glance the decrease in pH value of the soils with increase of altitude.

In the present study it has not been possible to differentiate between the three communities, viz., Blue pine, Blue pine-deodar, and deodar from one another on humus characters. Significant differences have been found between spruce and silver fir communities in regard to % loss on ignition and calcium content in surface layers of the soil and can be used to differentiate between the two communities.

Table III gives corresponding results for all the constituents except nitrogen based on average of the lower layers of each profile, excluding the top layer. A comparison of corresponding values of Tables II and III shows that in the lower layers both organic matter and calcium are much less than in the top layer but there is only a slight decrease in pH. These data agree closely with those of earlier workers (Taylor and others, *loc. cit.*, Hoon and Dhawan, *loc. cit.*).

In Table III significant differences between soil types are found only in mean pH values and they are of the same order as in Table II. Mean value of % loss on ignition are significantly different between spruce and silver fir communities. Both % loss on ignition and calcium content are significantly different between deodar and Blue pine communities.

The relationships between the various constituents of the humus were examined by a detailed correlation analysis, the results of which are presented in Table V. Since significant differences were found in the mean values in each soil type the total correlations given in the bottom line will not by themselves be a clear guide as to the existence of correlation if this factor and the factor of forest community were eliminated. The correlation coefficient shown against "within communities" are the appropriate measures of intrinsic relationship between the constituents of the humus. We notice highly significant positive correlation coefficient between

1. Organic matter and calcium content.
2. Organic matter and nitrogen.
3. Calcium content and nitrogen in the top layer of the profile.

These show that increase (decrease) in any of these three constituents is accompanied by increase (decrease) in the other two. We also notice a significant negative correlation between pH and organic matter content in the top layer showing that an increase (decrease) in pH is accompanied by a decrease (increase) in organic matter.

The correlation coefficient between pH, organic matter and calcium for the lower layers are given in the last three columns of Table V. It will be seen that there is a positive correlation between organic matter content and calcium, although this value (0·437) is much less than the corresponding value (0·713) for the top layer of the soils. This may be due to the presence of mineral Ca in the lower layers of the soil.

TABLE V

Values of coefficients of correlation between various pairs of constituents of the humus

Source of variation	Degrees of freedom	Based on top layer only						Based on average of all the layers excluding top layer		
		r_{12}	r_{13}	r_{14}	r_{23}	r_{24}	r_{34}	r_{12}	r_{13}	r_{23}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Between altitudes ..	2	−0·989	−0·918	−0·950	0·966	0·985	0·996	−0·995	−0·900	0·854
Within altitude between communities ..	3	0·489	−0·037	0·857	0·853	0·822	0·481	−0·841	−0·667	0·403
Within communities ..	31	−0·386*	−0·139	−0·344	0·713†	0·671†	0·462†	0·237	0·342	0·437*
Total	36	−0·507†	−0·379*	−0·518†	0·790†	0·744†	0·607†	−0·160	−0·056	0·487†

Note :—(x1) = pH ; (x2) = % loss on ignition ; (x3) = Ca in Millequivalent ; (x4) = % N.
* Indicates significance at 5% level of probability.
† Indicates significance at 1% level of probability.

It was thought worth while to see if the existence of high correlation between organic matter, calcium content and nitrogen could be made use of in evolving a prediction formula for the quantity of calcium and nitrogen present in the humus by determining only the quantity of organic matter in the Humus. For this purpose graphs I, II for the top layer and III for the average of lower layers of the soil were prepared and regression lines fitted taking % loss on ignition as the independent variable. These regression lines are based on the total correlation coefficients given in the bottom line of Table V and are, therefore, to be taken as "over-all" prediction formulae for the sampled area as a whole. On these graphs the points representing profiles belonging to the three different soil types have been separately marked. Each of the three groups of points seem to be evenly distributed about the regression line.

The individual points in all the three graphs show a wide scatter about the fitted regression lines. So the predicted values of calcium content and nitrogen content for a particular soil sample obtained by determining only the amount of organic matter in it and substituting in the equations of the lines shown in graphs I, II, III will be subject to a large standard error of 12·86, 0·19 and 8·88 respectively for the three graphs. It follows, therefore, that if calcium contents of the top layer of soil profiles are sought to be predicted from the amount of organic matter, using the equation given in graph I, the actual and the predicted values may differ by more than 26–27 millequivalents in 1 out of 20 profiles. Similarly, if equation given in graph III is used for the same constituent in the lower layers of the profiles the actual and predicted

values will differ by more than 16–17 millequivalents in 1 out ot 20 profiles. Similar margin of divergence between actual and predicted values of % nitrogen in the top layer using graph II will be about 0·38. These errors of prediction are quite substantial and seem to show that apart from organic matter there may be other factors that influence the quantities of calcium and nitrogen and such a conclusion is not unexpected ; for the calcium and nitrogen content of soils is influenced by several factors such as (1) composition of the organic matter (2) calcium content and pH of the soil (3) micro-organisms in the soil (4) atmospheric temperature and moisture.

With a view to see the influence of the composition of the organic matter on the humus fully grown mature leaves of the conifers and associated species collected in the months of May–June 1949 were analysed for ash, Ca, carbon and nitrogen. The data are presented in Table VI below :—

TABLE VI

	% Ash	% Total CaO	% Carbon	% N	C/N
Pinus longifolia	3·57	0·56	48	1·54	31
Pinus excelsa	3·78	0·98	47	1·83	25
Quercus semecarpifolia	4·05	1·57	46	1·76	24
Abies webbiana	4·70	1·59	42	1·56	26
Quercus dilatata	4·88	1·65	46	1·93	23
Cedrus deodara	5·25	1·80	43	1·23	38
Quercus incana	5·73	2·00	47	2·04	23
Picea smithiana	7·29	2·24	46	1·15	40
Alnus nitida	10·38	2·29	44	3·72	11
Populus ciliata	8·10	2·35	..	..	..
Juglans regia	13·45	2·42	42	3·36	12
Aesculus indica	10·42	3·34	44	3·11	14
Prunus padus	12·05	3·41	43	3·51	12
Cornus macrophylla	14·95	5·6	..	..	..

It will be seen that there are slight differences in N and CaO content of the foliage of different conifers and C/N ratio in different species is some different. It is interesting to note that broad-leaved species occurring in spruce and silver fir communities have very high percentages of Ca and Nitrogen and low ratios of C/N—which are beneficial in bringing about decomposition of tree litter and releasing CaO and Nitrogen. It seems that the high amounts of Nitrogen and Ca in Brown earth soils are not determined by the composition of the leaf-litter alone but it may be due to low temperature and high moisture content prevailing at such altitudes which inhibit the decomposition of plant material and increase the amount of humus and also the amount of calcium and nitrogen in those soils. Data on these points are at present lacking, and will be collected as opportunity arises ; further discussion on those points has thus to be postponed till then.

From the C/N ratio and calcium content in leaves of broad-leaved species of *Aesculus indica*, *Prunus cornuta*, *Cornus macrophylla*, *Juglans regia*, etc., an interesting point arises showing that mixture of conifers with these species will, perhaps, produce better conditions for litter decomposition and perhaps better conditions for conifer regeneration. The importance of this fact is recognized by foresters in this country (See Suri, 1932) who advocate that soils under mixed forests are generally more favourable for the regeneration of conifer species. We have not been able to collect specific data on these questions though high amounts of nitrogen and high base saturation of these soils would probably assure a mixed regeneration of conifers and broad-leaved species rather than purely of conifer species.

This study tends to show that conifer communities in the area studied could be classified on the basis of humus and soil types. Although, with the limited data, it has not been possible to demarcate clearly between the Blue pine and Deodar communities, the indications are that with further work this could easily be accomplished.

(*to be continued to Feb. 1951 issue*)

TEAK DEFOLIATION*

BY DR. K. KADAMBI

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Most foresters working in the teak forests of India have repeatedly watched the annual or periodical return of the defoliating caterpillars to their plantations, and they may have also noticed that the intensity of defoliation varies from time to time, and in the same season from locality to locality. Those who are managing coherent stretches of pure teak crops would also have observed that teak trees standing within a fairly restricted area shed their leaf† on different dates, and it is also common knowledge to them that the date of leaf shedding at the onset of the dry weather and afoliation at the commencement of the growing season varies generally with the availability of sub-soil moisture ; that this periodicity of leaf shedding is sometimes also independent of external factors and is, therefore, considered *inherent* is also known to all foresters but, except the few persons who have taken closer notice of the dates of hot weather defoliation, others would not have observed that occasional solitary trees are, for some unknown reason, able to retain their leaves *much longer* into the shedding season, and that their behaviour is constant from year to year.

Last June I had an opportunity to make a fairly intensive examination of the teak plantations of Nilambur, which had suffered a medium-heavy defoliation. I have watched the causes leading to the defoliator attacks on teak in the forests and extensive teak plantations of Mysore, and those of Malabar and Wynaad which I have had opportunities to visit repeatedly and at fairly regular intervals, in the past twenty years or more. The results of long-standing observations on the subject were confirmed and greatly strengthened by my recent field study of the subject in Nilambur and South Coimbatore divisions, and I, therefore, venture to place the following information on record so that it might serve as jumping off ground for others interested in this line of study. Among the factors influencing the severity of defoliation in any season are, apart from the causes which directly affect the multiplication of the insect over which we have little control, the following:—

(1) The condition (tenderness) of the leaf blade,

(2) The date of emagence of the larva in the leafing season,

(3) The possibility that leaves of certain trees are inedible to the caterpillar due to (i) leaf texture ; (ii) chemical composition, and are therefore insect repellant,

(4) The possibility that certain trees are inherent early sprouters, and therefore escape defoliation as they are too tough by the time the insect emerges,

(5) The possibility that certain trees sprout so late in the season that they escape destruction because the peak of the insect attacks in the season is missed, or the larva will perhaps be pupating by the time the leaves unfold.

The condition (tenderness) of the leaf.—The severity of defoliation seems to be intimately connected with the condition of the leaf blade at the time the defoliating larva emerges. According to Beeson, (1) for the 1st–instar larva the quality of the food is more important than the species ; very young larva must have soft, young leaf-tissue of any species of food plant and cannot survive on a diet of old leaf. I have, time and again, observed that if when the larva is in its earliest instars the leaf is also tender, i.e., has just unfolded from the bud, the larva seems to

* Leaf stripping by defoliating insects.

† Natural, hot weather leaf shedding.

thrive as it requires juicy, tender leaves to feed upon; if, on the other hand, the teak leaf is already advanced in its development the young larva may fail to work it down with its tender mandibles. In the dry, hot season *Hyblœa peura* is scarce and may even æstivate in an extreme climate. In the SW.-monsoon rainy season it increases in abundance provided the rainfall is within certain limits or periods but in regions of very heavy rainfall it does not multiply. In Nilambur the season of abundance is April to early June. In other words, the earlier the teak afoliates in the growing season the better it will be able to resist defoliator attack, and the later it comes to leaf the easier is its leaf likely to fall a prey to the defoliator. This is probably also the reason why leaves of coppice shoots are found to suffer less than those of seedling trees; the leaves of the former emerge earlier in the growing season, as most foresters may have noticed.

Early or late sprouting of teak may depend upon several factors. Among them are :—

(*a*) *Edaphic factors*.—It is a well known and frequently admitted fact that in tropical climates, where frost is not factor to be reckoned with, the availability of soil moisture controls the date of leaf shedding or sprouting in the season. This is the reason why teak plantations, standing next to a river bank, keep their leaves late into the shedding season. Throughout my long drawn-out wanderings in mixed-deciduous teak forests and pure plantations of the species I have invariably found that proximity to a river bank is a more or less certain guarantee for the relative capacity of teak to resist defoliator attack, and in these places it is common observation that trees shed their leaves later in the dry season and sprout earlier than elsewhere, the leafless period being, therefore, comparatively the shortest. I wish to quote, hereunder, the following extract from my note on this subject published some thirteen years ago. "Where the river banks are very high teak defoliates* earlier owing to the relatively low power of river alluvium to retain moisture, where they are too low the soil is saturated with water for several months in the year. Where the depth of river alluvium is optimum, i.e., neither too much not too little, this fact is indicated by the long retention of foliage by the teak during the dry season. Where soil depth is greater than the optimum, the trees have to close their growing season fairly early. Mere proximity to running water is by no means a guarantee for the good growth of teak. *It is the depth of water-level below the ground surface during the months succeeding the monsoon that is the main factor in affecting the growth of teak*". (2) The above explains also the reason why in some cases proximity to a river does not guarantee the success of a teak plantation.

In Mysore, as in other parts of India, the incorrect notion that proximity to running water is the sole criterion for the successful regeneration of teak, prevailed till about the end of the last century, and one finds that the plantations then formed are situated mostly adjoining rivers or major forest streams. The plantations along the Kabini river such as the Manchagowodanhalli plantation of 100 acres (the forest lodge plantation of 1887–88), the *Peel-khana* plantation of 20 acres (1890–91), the Mastigudi old plantation, the *Khedda*—store and other plantations opposite the Kakankote bungalow, the Kapila group of plantations of 105 acres near Begur (1891–93)—and the plantations along the Tanga river namely the Kanive group of plantations at Sakrebyle in Shimoga district (1858–64), are all successful examples of such river-side plantations. Teak has disappeared altogether from a portion of the area where soil drainage is inadequate for this species, and it has been replaced by the big bamboo (*Bambusa arundinacea*), but that which has remained behind contains some of the best bits of artificially regenerated teak forest we have in Mysore to-day. It is a noteworthy thing that these plantations do not suffer from very heavy defoliation of the kind seen in Nilambur. With the turning of the century the silvicultural demands of teak began to be studied in more detail, and the influence of soil drainage on teak growth was soon realized. The old idea that proximity of running water is an essential factor for the success of a teak plantation was given up and plantation sites were selected all over the forest where the soil and drainage were found suitable. (3)

* This refers to the seasonal leaf shedding of teak.

The greater part of Mysore's teak plantations date back to the period between the two great world wars, and it is in portions of these that the severest defoliation usually occurs.

In Nilambur, too, I have seen time and again that proximity to a stream affords, to some extent, a safeguard against very severe defoliation (Figs. 1 and 2). I quote below a few examples noticed during my recent visit :—(i) *Teak plantation in Edacode, Compartment 76*, second rotation crop 1845/1925........"The present crop has teak of III quality generally". ...."No teak defoliation (which is otherwise heavy this year) is observed in this plantation. The quality of the crop seems to fall as one proceeds from the river Kuruvampuza up the slope"...........

"But the following significant facts have to be observed in passing, as regards the thinned crop.—(i) The intensity of defoliation is generally less in the lower portions adjoining the river where, presumably, the sub-soil moisture is at a higher level than elsewhere" (4).

(ii) *Teak plantation in Nellikutha compartment No. 431.*—"First rotation crop of teak—1930, raised by dibbling seed". "This whole group of plantations adjoins the Ponnapuza river and runs more or less along its bank"........."*The plantation has escaped defoliation almost completely*. It is stated that it came to leaf much earlier in the season than the other neighbouring plantations, but this has to be verified by continued observation".

(iii) *Teak plantation in Nellikutha compartment No. 247.*—"Second rotation crop of teak—1871/1943"........."The plantation adjoins the Ponnapuza stream. A conspicuous thing noticed is *that defoliation is mild or absent close to the stream bank and increases progressively in intensity as we proceed away from it, indicating that the level of the sub-soil moisture has* some indirect influence on it".

(iv) *The 1948 teak plantation—New—Amarampalan range, First rotation crop.*—"The plantation area starts on the bank of Ponnapuza river and extends inwards, i.e., away from the river. There is practically no defoliation in the portion adjoining the river, but the plants have suffered heavily as one proceeds away from river bank".

(v) Teak plantation in compartment 317, 318 and 320, *Nidungayam ;* 1907—planted area. "The compartments above described (of Nidungayam) adjoin the river Karimpuza and there is no defoliation. The soil is also mostly river alluvium. This general resistance of the plantation adjoining rivers to defoliation leads to the presumption that proximity to a river is perhaps advantageous in this respect, and this assumption is further strengthened by the fact that in compartment No. 354, which is a short distance away from the river bank, defoliation has occurred in patches, its intensity increasing with the distance from the river bank".

(vi) *Plantation in Chatambarai compartment 193.*—"Second rotation teak crop 1873/1945"........"Owing presumably to its proximity to the Karimpuza river the plantation has resisted defoliation".

(vii) *Plantation in Chatambarai compartment 181.*—"Second rotation teak crop 1872/1943". "The general quality is I adjoining the river Karimpuza ; this goes on to II and III quality further on. Defoliation least near the river but increases in intensity progressively as we go away from it".

The foregoing examples are highly suggestive of the fact that while proximity to a river influences the intensity of defoliation to a considerable extent, defoliation intensity seems to be generally independent of crop quality. It must not be thought, however, that a river bank invariably offers protection against defoliation severity. For example, in the 1871—teak plantation of Nellikutha compartment 248, which now contains the permanent preservation plots Nos. 128, 129 and 130 and in which the teak crop has been retained beyond its rotation age, the trees which are now 79 years old have suffered heavy defoliation inspite of their proxi-

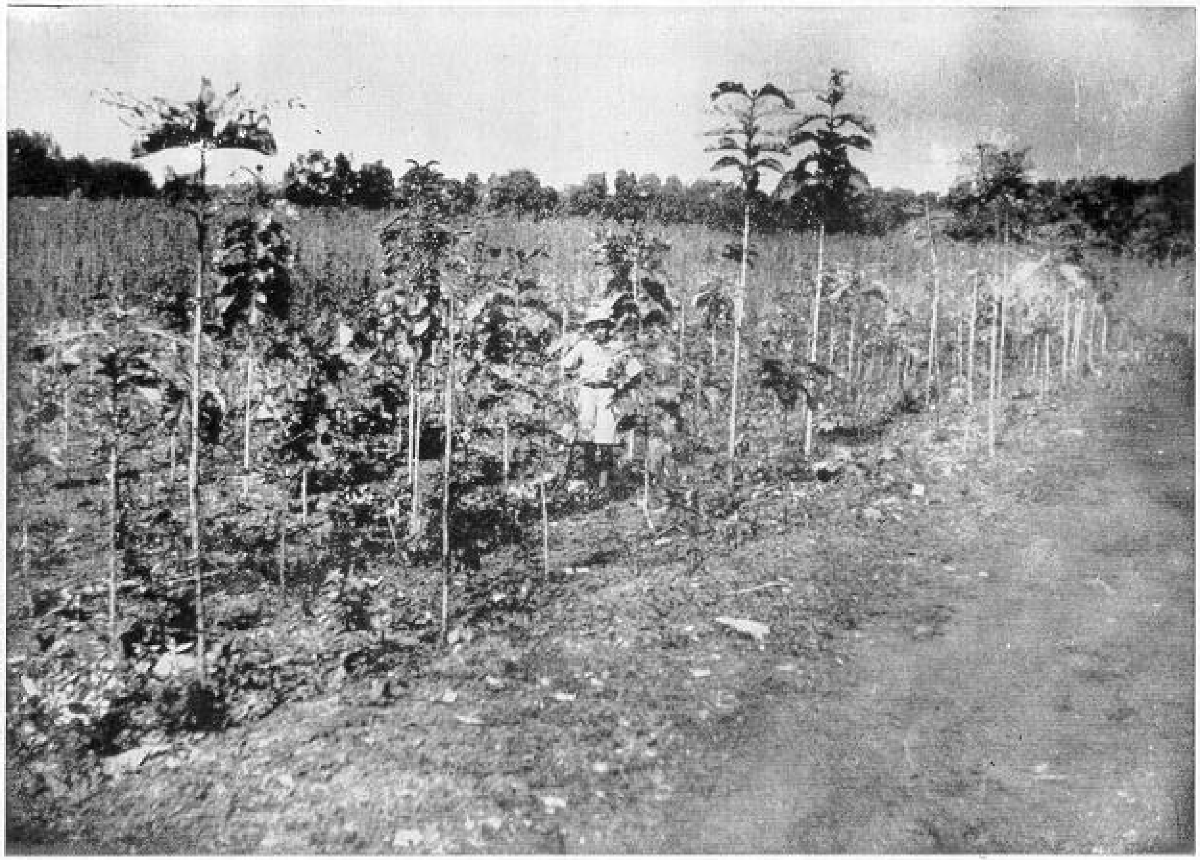

FIG. 1.—Teak, 1874/1947 crop, compartment 230, Old Amarampalam Range, Nilambur, Madras. Plantation about a furlong from the edge of a stream. Here the defoliation is moderately severe.

Photo. Author; June 1950.

FIG. 2.—The same plantation as in Fig. 1. Photographed at a place about two furlongs away from the edge of the stream. Here the defoliation is very severe. The small sized foliage found on some of the bare teak saplings are of the twiner *Dioscorea* sp., which is common in such plantations.

Photo. Author; June 1950.

FIG. 3.—Teak plantation 1871, Nellikutha compartment 248 (sample plot No. 129 of Nilambur), Madras. Crown-photograph of a tree which, though surrounded by other, almost completely defoliated, trees has resisted the defoliator attack.

mity to the stream Ponnapuza. It is *significant, however, that this is an old crop retained beyond rotation age* and, is the only exception to the general rule which I was able to find during my detailed inspections. Some observers have suggested that the increased humidity of the atmosphere adjoining streams is responsible for reducing the intensity of defoliation ; they believe that the humid atmosphere near streams is not very condusive to the growth and activity of the defoliator with the result that defoliation is relatively less in such places. This explanation does not, however, satisfactorily meet the instances in which severe defoliation has occurred even in stands adjoining streams. Evidence tends, on the whole, to strengthen the view that the severity of defoliation is indirectly connected with the availability of physiological moisture to the teak during the dry season.

(*b*) *Hereditary causes.*—That the hereditary factor plays a part, and perhaps an important one too, in deciding the intensity of defoliation in certain instances, is of little doubt. For example, in the All-India seed origin experimental plots of Kakankote (5) (South Mysore region) and Bandigudda (North Mysore region) I have invariably found that teak trees of Nilambur origin suffer most and those of local origin suffer relatively the least. The last fact, namely, that teak trees raised from local seed have suffered least in their own locality is of particular significance, and indicates that in any locality the local race is perhaps the most resistant to the defoliator.

Other, equally conspicuous evidence of the hereditary factor influencing the intensity of defoliation was observed in Nilambur this year. The following extracts from by tour notes are of interest:—

(i) *Teak Sample Plot Nos. 128, 129 and 130 Nilambur (1871-crop).*—"Inspite of their proximity to the stream Ponnapuza, defoliation of the trees in the plot is severe, *except for a single tree in plot No. 129*, which has completely withstood the attack, although all the leaves of the trees around it have been destroyed (Fig. 3). This interesting but extra-ordinary fact is noticed in some other teak plantations also".

(ii) *Teak Thinning Research Plot in Edacode Compartment 81.*—Second rotation crop—1848/1929 : "Amidst the heavily defoliated portions of the crop solitary trees are found which have more or less completely or partially resisted the defoliation. This is hard to explain or understand, unless we presume that : (i) the leaves of these individual trees are probably *more resistant* to the defoliator attack, (ii) these leaves are repellant to the caterpillars owing to something (a chemical ?) which they contain, or (iii) the texture of the leaves at the time of the emergence of the defoliating larvae, i.e., during the earliest instars of its life cycle—is such as to render it too tough and, therefore, inedible to the delicate, tiny-mouth—parts of the larvae ; i.e., these trees are early sprouters".

Such trees should be marked for closer observation and study of their phenology, leaf anatomy and the chemical constituents of their leaves. From the viewpoint of the control of defoliation by silvicultural means, it is a matter of vital importance to find out whether all these trees escaped the defoliator by mere accident—which seems highly improbable—or whether they came to leaf earlier in the season than their defoliated neighbours with the result that at the time the defoliating larvae emerged the leaves were already too tough and, therefore, inedible. If this surmise is correct, it has to be further studied whether the trees in question are in the habit, each year, of unfolding their leaves earlier in the season and if so, whether their seeds do also give rise to trees possessing similar characters. If, on the other hand, this is not so, then we have look for other possible causes which lead to the relative immunity of the leaf to defoliator attack ; among them may be,—(a) peculiarity in the anatomical structure of the leaf such as a thick layer of cutin, presence of glandular hairs, etc., on the leaf surface, or (b) the existence in the leaf of a chemical, repellant to the defoliator. The anatomy of the resistant leaves has to be worked out in full and such leaves also chemically analysed to discover the

causes leading to the defoliator immunity. There is, also, the likelihood that some teak trees sprout so late in the season that they escape severe defoliation as the peak of the defoliator attack is already past by the time the leaf unfolds or because the larval period is missed. The importance of making detailed phenological observations lie, therefore, along one of the main lines of research aimed at countering the defoliator attacks. The second line of attack lies in the genetical field. If the trees in question can also produce, through their seed, other trees possessing defoliator resistaining capacity, the defoliator problem is well neigh solved. All that may be required is to self-pollinate the flowers of such trees and propagate future trees from such seed.

If it is found that the above are not the causes then, in any particular year, the coincidence of the time of emergence of the larva and the time of early leafing of the trees is likely to decide the severity of the defoliation.

Influence of the life cycle of the defoliator on the intensity of defoliation :—

The progress of the life cycle may serve to neturalize or enhance the advantages of the early sprouting teak trees. The date of mass emergence of the defoliator in the season depends upon a number of factors, mostly climatological, over which we have little or no control. If, for instance, in any season the larva emerges earlier than usual this will be a handicap to the early sprouting trees, because the defoliator destroys the young leaf before it has time to develop ; and vice versa, if in any year owing to unfavourable climatic conditions, among which dry weather seems to be the most potent, the caterpillar emerges on a large scale later than usual, teak gets the advantage of additional time to harden its leaves, and defoliation damage must necessarily be less in such years. From the entomologist's point of view it would be advantageous to make detailed studies in this field of animal ecology. It has been suggested by some that very high atmospheric humidity is an inhibiting factor causing postponement of the date of mass emergence of the caterpillar ; this view may be correct but adequate experimental evidence is yet lacking to substantiate it.

The role of the undergrowth in teak defoliation :—

I am told that in Madras state a circular order is in force which prohibits the cutting away of the undergrowth in teak plantations as it has been recognized that in such plantations the undergrowth contains certain species which serve as secondary hosts of the defoliator and thus serves to reduce the severity of the attack on teak by providing an alternative diet to the larvae. *Helictres isora* is said to be one of the secondary hosts. A conspicuous illustration in support of the above was found in the Silviculturist's thinning research plantation of Edacode compartment No. 81 and the plantations adjoining it. The following is an extract of my field notes in this connection :—

"A noteworthy fact in connection with the crop of this compartment (Edacode, Cpt. No. 81) is that it has suffered heavy defoliation (Fig. 4) while the crop in the neighbouring compartments (Cpt. 76 and 82) are nearly free from this injury, or have suffered but little from it. As regards immediate past treatment, it has to be observed that the thinning research crop was subjected to a thinning in May 1950, i.e., hardly two months ago, while the crop in the neighbouring compartments was thinned 2 to 3 years ago. Another factor of difference in the treatment is that the undergrowth in the thinning research plot was cut back to a height of 4 feet at the time of the thinning while the neighbouring crops have had their undergrowth in tact". ...."Defoliation might have some thing to do with the undergrowth as we find a conspicuous difference between the area which has its undergrowth cut and that where it is in tact".

Edacode Cpt. 82.—Plantation of second rotation : 1849/1927. "This plantation adjoins the silviculturist's thinning research plot of compartment 81, where there is heavy defoliation this year, and inspite of it has suffered practically no defoliator attack (Fig. 5). In fact, the

FIG. 4.—Teak Plantation 1848/1929, Edacode compartment 81, Nilambur, Madras. Teak thinning research Plot. Thinned to a 'C'-grade by the Provincial Silviculturist in May 1950 and undergrowth cut back to 4 ft. height; heavily defoliated contrast Fig. 5.

Photo. Author; June 1950.

FIG. 5.—Teak Plantation 1849/1927, Edacode compartment 82, Nilambur, Madras. This plantation was thinned three years ago and is contiguous with the plantation shown in Fig. 4. Inspite of this, the crop has resisted the defoliator attack. The undergrowth was not cut back in this plantation, and consists of *Glycosmis pentaphylla*, *Clerodendron infortunatum*, *Helictres isora*, *Leea sambucina*, etc.

Photo. Author; June 1950.

crop of both the plantations cold be stated to be contiguous to each other, there being no belt of vegetation. natural or artificial, in-between them. The only visible difference is that the undergrowth has not been cut back here as was done in the silviculturist's research plot last May (1950), although in both of them the floristic composition of the undergrowth is similar—*Glycosmis pentaphylla*, *Clerodendron infortunatum*, *Macaranga roxburghii*, *Helictres isora*, *Leea sambucina*, *Curcuma* species. The district practice is not to cut back the undergrowth at the time of the thinning but the research section has cut it back to 4 feet height. The district plantation was last thinned in 1945–46, and its undergrowth is dense and fills most of the space up to one half the height of the teak crop. It would be a very interesting study to find out what exactly it is that has kept the crop in this plantation almost completely free from defoliator attack while its neighbour, whose edge is hardly 5 yards away from that of this plantation, has suffered severe defoliation (Fig. 6).

It is also likely that the thinning operation, to which the thinning research plots were subjected in last May, might itself have had some influence on the intensity of the defoliation. To clear these points, suitably planned experiments, somewhat on the following lines, may have to be laid down :—

Treatments :—I—*Influence of undergrowth on defoliation.*

(*a*) undergrowth to be completely removed and the operation repeated as often as required to keep the plantation free from it,

(*b*) undergrowth cut back to 4 feet height, as was done in the thinning research plots,

(*c*) undergrowth not cut.

(*a*), (*b*), (*c*) to be thinned as per normal district practice.

II—*Influence of the thinning—intensity on defoliation.*

(*a*) overwood unthinned as control with interactions of (a), (b) and (c) above,

(*b*) overwood thinned as per district practice—with .. .. do. ..

(*c*) overwood thinned to different degrees of intensity—a, b, c, d, e and x grades, with interaction of (a), (c) and (c) above.

Influence of a belt of non-teak tree growth on teak defoliation.—One other factor which has been claimed to influence defoliation was also observed in Nilambur, namely, that a narrow belt of cashew-nut trees which separates the teak crops between Edacode compartment Nos. 76 and 81 appears to have arrested the spread of the defoliator havoc.

The following field notes were made in this connection :—

Edacode Cpt. 76.—(13·7 ac.) ; Teak crop of 2nd rotation : 1848/1925. "The present crop has teak of III quality, generally. The last thinnings appear to have been unduly heavy with the resulting openings being in places too large, tending to form lasting breaks. Lateral branches heavy, probably on account of the heavy thinnings. No teak defoliation (which is otherwise severe this year) is observed in this plantation. The quality of the crop seems to fall as one proceeds from the river Kuruvampuza up the slope. Between this plantation and the next (in compartment 81) there is a belt of cashew-nut trees, and on emerging at the other end of this belt, we come across a heavily defoliated plantation, which is maintained at present as a thinning research plot". It has to be ascertained by actual experiment whether cashew-nut can serve as an effective barrier against the infiltration of the defoliator between neighbouring teak crops. It is surprising that the crop of Cpt. 81 has been almost completely defoliated while the crop of cpt. 76, whose edge is but a few yards away across the cashew-nut tree-belt, is almost entirely free from it, there being not even a noticeable vestige of leaf destruction in it. Besides taking steps to carry out phenological observations for a number of years in these adjoining crops to see if this difference in behaviour holds good every season, it would be advantageous

to actually raise belts of cashew-nut in-between teak crops to decide whether or not such a belt is useful.

Practical results of the foregoing field observations.—If it be established that by making soil moisture available to the root system of teak in the dry season and thereby facilitating the early sprouting of the tree we can control, or at least check, the intensity of defoliation, defoliation control in irrigated teak plantations could be achieved by regularizing the method and frequency of irrigation. Deep irrigation, by percolation, given at fairly long intervals of time, would tend to the development of a deep root system. If this can be achieved, the period during which the trees remain naturally leafless can be reduced to a minimum, and consequently also the susceptibility of teak leaf to defoliator attack would probably be less. Every measure aiming at reducing the leafless period will probably also result in reducing the vulnerability of teak to defoliator attack. In non-irrigated plantations, which are the rule, every measure taken to conserve soil moisture and make it available to the root system of teak trees in summer would perhaps also tend to reduce the intensity of defoliation. Thus, cross trenches made along contours within a plantation, soil-working, etc., may reduce the severity of defoliator attack. Control of the defoliator will perhaps also become possible by modifying our present silvicultural practice of cleanings and thinnings. In this connection I have to mention of our experience in Mysore teak plantations, where the undergrowth is left intact and thinnings are done neither so frequently nor so heavily as in Nilambur ; probably in consequence of this treatment, defoliation is hardly ever so severe as in Nilambur. If it is not possible to keep the defoliator out completely, there is every hope that its severity can be kept within reasonable limits by altered silvicultural practice.

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KUTH CULTIVATION IN LAHAUL AND ITS FUTURE

BY D. P. SINGH

SUMMARY

Kuth grows naturally in forests of Kashmir while in Lahaul it was first introduced in 1923 from Kashmir and since then it has been the most important cash crop in the valley. On account of suitable soil conditions and irrigation facilities Kuth grows well in all parts of Lahaul below 10,000 feet. Cultivation is not a difficult matter and is now well understood by the people. The main market for Kuth lies in China and due to Civil War there, the market is very dull and consequently the cultivation of Kuth and people's economy in Lahaul has received a serious set-back. It is now for our trade agents in China to come to people's rescue and guide them on the matter. Fearing that Kuth cultivation may have to be abondoned ultimately the Forest Department has already commenced work on providing substitutes in Ephedra and Artemesia to Lahaul people.

The original home of Kuth is Kashmir where it grows wild in the forests and is a monopoly of the State. In Lahaul unlike Kashmir it is an agricultural crop and was introduced about 25 years ago.

CHARACTER OF THE PLANT

Kuth (Saussurea Lappa) belongs to the family—Compositeae. The plant is a tall and robust herb. The stem is up to 1 inch thick and attains a height varying from 5 feet to 9 feet. It has no branches but large scabrous leaves grow out of the stem. The radical leaves are 2–3 feet long including the petiole which is lobately winged—the terminal lobe often 1 foot in diameter. The cauline leaves are only 6 inches to 12 inches long including the petiole, base auricled ; all membranous, scabrous above, glabrous beneath. The flower heads are hard ; dark purple in colour, 1–1½ inches in diameter and grow out in axils of leaves or in terminal clusters of 3 to 6—greater number near the top and smaller number lower down. The seeds are in the form of achenes which are glabrous with tops contracted or cupped.

The root which is the valuable part of the plant is carrot-shaped and has a characteristic smell both fresh and when dry. In older plants several roots are joined together.

The plant has certain peculiarities at different ages which are noted below :—

(i) One year old—Consists of only leaves and there is stem but few flowers.

(ii) Two years old—Attains an average height of 2 feet and contains some flowers.

(iii) Three years old—Attains an average height of 4 feet with about 10–20 flowers.

(iv) Four years old is full grown plant with an average height of 5–7 feet and the flowers heads increase in number and size.

INTRODUCTION AND EXTENSION OF KUTH IN LAHAUL

Cultivation of this plant was first commenced in 1923 by Shri Jomga Phanchok of Goshal after obtaining seed from a Vaid in Nurpur in Kangra District, who probably got this seed from Kashmir. The earliest entry in Revenue Records was made in 1930–31 when only

14 *biswas* were sown as cultivated under Kuth. In subsequent years the cultivation progressed as follows :—

Year	*Area*		*Kothi in which grown*
1931–32	1	Acre	Tandi, Ranika, Warpa, Goshal and Kolong.
1932–33	10	Acres	In all the 14 Kothis of Lahaul except Barbog, Karding and Khokhsar.
1933–34	15	,,	Extended to all Kothis and yielded the following quantities :—
1934–35	24	,,	318 Maunds.
1935–36	120	,,	1,479 ,,
1936–37	140	,,	2,811 ,,
1937–38	296	,,	4,876 ,,
1938–39	430	,,	6,000 ,, Approx.
1939–40	485	,,	do. ,, ,,
1940–41	374	,,	do. ,, ,,
1941–42	421	,,	do. ,, ,,

Since 1942 the area under cultivation and total production of Kuth have considerably decreased on account of fall in prices as a result of Civil War in China which is the ultimate market.

FACTORS AFFECTING GROWTH

As noted above 'Kuth' grows wild in Kashmir presumably because of more rainfall and decaying leaves from forest trees which bring about suitable conditions of moisture and soil. In Lahaul the altitude never falls below 9,000′ and this factor suits Kuth cultivation admirably. The deficiency of rainfall is made good by irrigation—a unique feature of Lahaul agriculture. In some cases snow is brought from higher altitudes and is put on beds to increase moisture. The plant likes soft porous soil and does not tolerate water-logged spots. On account of good soil conditions and irrigation facilities 'Kuth' grows well in all parts of Lahaul below 10,000 feet particularly in Pattan valley where factors are most suitable.

TECHNIQUE OF CULTIVATION

(*a*) *Preparation of land and sowing.*—The land is ploughed or dug up, levelled, and manure is mixed. Thereafter ½″ deep lines are dug at a distance of 6 inches with a small stick. Seed is then sown in twos or threes at a spacing of 4–6 inches. The line furrows are then covered with soil. The method is particularly adopted when the seed quantity is limited and cost on the seed has to be saved. Otherwise once the field has been prepared seed is broadcast as uniformly as possible and covered with soil by the ploughshare. Sowings are carried out in November–December or May–June. One acre may require 8–12 seers of seed depending upon the method of sowing. Before sowing the seed is soaked in water. This process softens the seed and makes germination easier. After sowing, the seed should be covered with soil or straw to prevent drying up with the heat of the sun.

(*b*) *Subsequent attention.—First Season.*—The seed remains under snow throughout the winter in case of autumn sowings and germination takes place after snow melts. Watering and weeding are then started and continued at intervals throughout summer until the snow-fall. Watering is done once a week depending upon weather and the total waterings during the

season may be about 12. Weedings are carried out as often as necessary. Fresh leaves grow out each month and the growth in the first season may be about 6 inches above ground (see Photo I). At the same time the tap root gets established about 6 inches below the ground (see Photo IV). Before winter, in November–December, the leaves start falling and when snow-fall occurs the stem gets burried and destroyed.

Second Season.—The plants re-appear in March–April—a couple of weeks after melting of snow and attain a height of about 2 feet by about the end of the season (see Photo II). The soil is loosened around roots so that they can expand. Some more manure is also applied where soil is rather poor. Regular watering and weedings are again carried out. The tap root attains a size of 2″–3″ in diameter and about 1–1½ feet in length (see Photo IV).

Third Season.—Before snow-fall the leaves are again shed, and stem is destroyed ; fresh leaves appear after melting of snow. This year only watering is necessary and no weedings are required as the leaves are so thick that they do not allow anything to grow under. The growth is rapid and the plants attain an average height of 6 feet. Flowering takes place from July–September and seeds are ready by the end of October.

HARVESTING

The heads are collected, dried in the sun and seed is beaten out of them with a stick. It is then stored in pots where it may last for three years. One acre may give 20–25 seers of seed. The stems are also cut, dried and used as fodder during winter. The roots are also dug out, earth removed from them, cut into pieces up to 4 inches long, and dried by spreading in the sun on roofs of houses. After drying, the root chips are packed in bags and exported outside Lahaul. The average yield may be 20 to 30 maunds per acre. The practice of digging out roots varies from three to four years—3 years being the most common. Healthy 3 years old plants sometimes yield a root weighing 2 seers but usually only ½ to 1 seer, when wet. On drying only ¼ is left out of a seer.

DISPOSAL AND MARKET

From Lahaul Kuth is brought to Kulu and sent on to Amritsar and Calcutta. The ultimate main market is China where it is burnt as a sacred incense. The roots give out a perfume resembling violets and hence are greatly in demand for ritualistic purposes. A small proportion is also used in India for protecting warm clothes against insect attack and for medicines by Vaids and Hakims. At one time there was lot of smuggling of Kuth from Kashmir, and it was found necessary to regulate export of Kuth by issue of a permit by the D.F.O., Kulu. With increased production and formation of "Kuth Growers Association" there was insignificant smuggling and the practice of issuing permits was abolished before the last War.

FUTURE

Kuth cultivation is by far the most important source of profit to the people of Lahaul and nearly every villager has a patch or two. At one time when its price shot up to Rs. 240 per maund people considered its cultivation more profitable than buckwheat, rye, etc. The market for Kuth is considerably dull these days on account of Civil War in China. The total area under cultivation during 1948–49 was about 150 (1–2% of the total cultivated area) at a prevailing price of Rs. 30 per maund. The area under Kuth has further decreased this year so much so that people have started growing food crops between the spaces made available in Kuth crop. Over 10,000 maunds of Kuth is lying unsold in various godowns and there seems

little hope of disposing off such large stocks. The people of Lahaul are getting nervous about their agricultural economy. The position at present is that there is little profit in Kuth cultivation. But as it happens to be the main stay of the people they cannot also leave its cultivation unless they know more definitely about future of Kuth and find an alternative means of substantiating their income. It was hoped last year that with the virtual close of War in China there would be increased demand for Kuth and consequent better prices and thus bring relief to the people but as it is, such hopes have been frustrated. People are now looking forward to Government for obtaining information from China through our Embassy or Trade Commissioner whether there is any likelihood of increased demand for this commodity or not. If there is reasonable demand then people would continue cultivation of this essential export commodity otherwise they would abandon it and concentrate on Ephedra and Artemisia where the prospects seem hopeful as a result of preliminary study carried out by Forest Officers on the matter.

FORESTS CATCHMENT AREAS AND WATER SUPPLIES

BY PROFESSOR E. P. STEBBING, M.A.

(*Fellow of the Linnean, Royal Geographical Society, of the Royal Society of Edinburgh. Honorary Member of the Society of American Foresters, formerly of the Indian Forest Service, now Head of the Department of Forestry, University of Edinburgh*).

PART II

(*Continued from the* " Indian Forester ", *January 1951, page 23*)

COUNTRIES DEALT WITH

AMERICA, ETC.

United States
Canada
Newfoundland
South America
British Honduras
British Guiana
Trinidad
Jamaica
West Indies

AUSTRALASIA

Australia
New Zealand
Tasmania

HINDUSTAN AND THE FAR EAST

India
Pakistan
Burma
Ceylon
Malaya and Sarawak
British Borneo
Indonesia
Siam
French Indo-China
China
Japan

AFRICA

East and West Africa
Nyasaland
Kenya
Uganda
Tanganyika
West African Rivers
Sierra Leone
Liberia
Nigeria
Gold Coast
Togoland
Cameroon
French Ivory Coast
French Equatorial Africa
Belgian Congo
Portuguese East Africa
Sudan and The Nile
Northern Rhodesia
Southern Rhodesia
South Africa
Madagascar
Mauritius

MIDDLE EAST

Egypt
Israel
Lebanon
Turkey
Iraq
Saudi Arabia (No information available)
Persia (Iran)
Transjordan
Cyprus

PART II

AMERICA, ETC.

UNITED STATES

All the world is acquainted with the disastrous results of the cultivation methods on a rich soil over a period of years which led to the formation of the great Dust Bowls in the United States and Canada. It is sufficient now to say that the over utilization of the soil in the production of wheat and cotton has resulted in some 900 million acres of land in the North, Central and North Western States being ruined and sometimes even larger areas on their outer perimeter.

Disafforestation on the major scale in the Catchment Areas of big rivers results in floods of the gigantic type as exemplified by the Mississippi-Ohio-Missouri river system repeated more than once during the present century.

In 1943 C. A. Connaughton, Director, Rocky Mountains Forest and Range Experimental Station wrote :—

> "Service of Watersheds is one of the most important contributions that wild mountain lands make to the semi-arid West. Their utility for watershed purposes is influenced by a number of factors, of which those associated with the kind and density of vegetation may be manipulated in co-ordination with other uses to obtain optimum yields of usable water. Since the benefits of land management for water yield may often be less direct than the returns from other resources, land managers are cautioned to guard against subordinating watershed services to other uses at the expense of the public welfare".

Advice which has fallen on deaf ears in many parts of the world, one of them being his own country. But this trouble is becoming yearly more apparent.

Later, from this same North Rocky Mountain Forest Experimental Station a paper was published entitled "A Watershed Protection Program", by L. F. Watts, Director, E. N. Munro, Chief, Division of Silvics, W. R. Chapline, Chief, Division of Range Research, and Luther G. Schnur, Associate Silviculturist, Alleghany Forest Experiment Station. It formed part of a large Report called the "Copeland Report of March 1933" issued by the U.S. Forest Service in response to a Senate resolution requesting information on the forest problem in the United States.

The paper deals with this subject under the heads "Influence of forest cover" "Relation of ownership to watershed conditions" "Major critical situations" and, "Program for adequate watershed protection".

No one doubts now-a-days that both river flow and erosion are greatly influenced by the kind of tree and other vegetative cover on the ground. Serious interference with the all protecting forest or other vegetative cover brings about unforeseen consequences. The writers of the above paper say :—

> "Profound changes, it is evident, have taken and are taking place in the regimen of our streams, and undesirable soil movement has taken and is taking place on great areas of watershed land. These changes, usually harmful in their effect, have been shown to be largely the result of imporper use of forest, range, and farm land".

The amount of use the forest or other vegetation has depends upon (1) the type and condition of the forest, (2) the characteristics of the soil, (3) the topography, (4) intensity and purpose of water use.

These are all well known to the forester. The surprising thing is that in the United States stronger steps have not been taken years ago to at least lessen the depredations of the uncontrolled lumberer and excess grazier even though both may have been operating on their own lands.

"The simplest measurement to use when comparing the size of rivers is length", says a *Geological Survey Circular* 44 (May 1949) entitled "*The Large Rivers of the United States*", prepared by The Water Resources Division. "Length is most meaningful in comparing navigable rivers. The thousands of miles of navigation afforded by the Mississippi-Ohio-Missouri river system played a large and significant part in the development of the interior of our country. The great navigable length of the Missouri made it an important arterial trail to the West. It is interesting to consider the profound extent to which the settlement of the West might have been altered had the early Spanish settlers in Mexico been able to ascend the Colorado by boat".

Other great countries have shown the same thing in the past and some up to present times. In India, the Ganges, Indus and Brahmaputra; and the Irrawaddy in Burma. In Europe, the Rhine, Danube, Volga and the Northern Dvina and so forth. The rivers were the highways, roads being rare or non-existent and the railway unknown. In fact rivers have played a larger part in the destiny of the human race than has been appreciated. The Circular continues :—

"Rivers may also be compared in relation to the size of the basin drained. Drainage area is a measure of the region contributory to a river, but is not so much a characteristic of the river itself.

"It is the flow of water in the river that turns the wheels of industry, supplies water for cities and for innumerable industrial processes and maintains navigable depths for shipping. Consequently the flow of a river is perhaps the most significant index of its utility in a highly productive country. It tells us how much water the river can supply for development. Therefore, in this report rivers are classified with respect to their flows. Their lengths and their drainage areas are listed for subsidiary classification".

TABLE 2

Large rivers in the United States in order of average discharge at mouth
(First order tributaries marked T, second order tributaries marked TT)

Rank	River	Length (miles)	Drainage area (square miles)	Average discharge (1921–45) (cub. ft. per second)	Most distant source	Mouth
1	Mississippi ..	a3,892	1,243,700	b620,000	Source of Red Rock River, Mont.	Gulf of Mexico.
2	Ohio (T)	1,306	203,900	255,000	Potter Co. Pa.	Mississippi River.
3	Columbia	1,214	258,200	235,000	Columbia Lake B.C.	Pacific Ocean.
4	St. Lawrence ..	..	c302,000	c226,000	..	..
5	Mississippi above Missouri River (T) ..	1,170	171,600	91,300	Lake, Itasca, Minn.	Confluence with Missouri.
6	Missouri (T) ..	2,714	529,400	70,100	Source of Red Rock R. Mont.	Mississippi River.
7	Tennessee (TT) ..	900	40,600	63,700	SW. Virginia	Ohio River.
8	Mobile	758	42,300	59,000	NW. Georgia	Mobile Bay.

a The length from mouth to source of Mississippi River in Minnesota is 2,350 miles.
b About 25 per cent of the flow occurs in the Atchafalaya River.
c At international boundary lat. 45°.

(*contd.*)

TABLE 2—(*concld.*)

Large rivers in the United States in order of average discharge at mouth
(First order tributaries marked T, second order tributaries marked TT)

Rank	River	Length (miles)	Drainage area (square miles)	Average discharge (1921–45) (cub. ft. per second)	Most distant source	Mouth
9	Red (T)	1,300	*d*91,400	*d*57,300	Eastern edge of New Mexico.	Mississippi River.
10	Arkansas (T) ..	1,450	160,500	45,200	Lake Co. Colo.	Do.
11	Snake (T) ..	1,038	109,000	44,500	Ocean Plateau Teton Co. Wyo.	Columbia River.
12	Susquehanna ..	444	27,570	35,800	Otsego Lake Otsego Co. N.Y.	Chesapeake Bay.
13	Alabama (T) ..	720	22,600	31,600	Jacks Creek NW. Georgia	Mobile River.
14	White (T) ..	690	28,000	..	Madison Co. Ark.	Mississippi River.
15	Willamette (T) ..	270	11,250	30,700	Tumblebug Cr. Douglas Co. Oreg.	Columbia River.
16	Wabash (TT) ..	475	33,150	30,400	Darke Co. Ohio	Ohio River.
17	Cumberland (TT) ..	720	18,080	27,800	Poor Fork Letcher Co. Ky.	Do.
18	Illinois (T)	420	27,900	27,400	Source of Kankakee River Joseph Co. Ind.	Mississippi River.
19	Tombigbee (T) ..	525	19,500	27,000	NE. Mississippi.	Mobile River.
20	Sacramento	382	*e*27,100	..	Siskiyou Co. Calif.	Suisan Bay.
21	Apalachicola ..	500	19,500	25,000	Towns Co. Ga.	Gulf of Mexico.
22	Pend Oreille (T) ..	490	25,820	24,600	Near Butte, Mont.	Columbia River.
23	Colorado	*f*1,360	*f*242,900	..	Rocky Mountain Nat. Park, Col.	..
24	Hudson	306	13,370	21,500	Essex Co. N.Y.	Upper New York Bay.
25	Alleghany (TT) ..	325	11,700	19,200	Potter Co. Pa.	Ohio River.
26	Delaware	*g*390	*g*12,300	19,000	Source of West Branch Schohari Co. N.Y.	Delaware Bay.

d Flow of Ouachita River has been added.
e About.
f At Arizona–Sonora boundary ; natural flow not accurately known because of large depletions for irrigation.
g At Deepwater Point on Delaware Bay.

The following rivers, mainly in the south-west, have large drainage areas but relatively low average flows. They are listed according to drainage area, and are believed to discharge less than 10,000 cft. Colorado river above its junction with Green river in Utah is believed to be the largest in the group on a flow basis.

	Sq. miles		Sq. miles
Rio Grande	171,585	Green River (Utah-Wyo) ..	44,400
Platte River	90,000	Colorado River (Texas) ..	41,500
Kansas River	61,300	Pecos River	38,300
Gils River	58,100	Canadian River	29,700
Brazos River	44,500	Colorado River (above Green R.)	26,500

Yukon river, which rises in Canada and flows through Alaska to the Bering Sea, is estimated to have an average flow of about 150,000 cubic feet per second. It is about 2,300 miles long and drains an area of about 330,000 square miles.

As a typical example of a plan useful in the investigation herewith being undertaken the one showing the Mississippi tributaries see frontispiece given in the Geological Survey Circular from which this reproduction is taken with permission is here given. For the Mississippi river of the length listed, i.e., the distance along the stream from the Gulf of Mexico to the source of Red Rock river in the upper Missouri river basin in Western Montana.

> "The Mississippi early named "Father of Waters" is the greatest river by all standards of comparison,—flow, drainage area, and length of its tributaries or components. 11 are included among the ranking 26 rivers in the United States. The Mississippi together with a parallel distributary, the Atchafalaya, discharges the water that drains from 40 per cent of the land area of continental United States. Table 2 shows that the Ohio, Columbia and St. Lawrence rivers are respectively second, third and fourth ranking rivers in respect to flow. There is a large difference in the discharges of the fourth and fifth ranking rivers given in Table 2. The upper Mississippi river has only about 40 per cent of the flow of the St. Lawrence river which occupies the fourth position in the list. The differences in flow of the remaining streams become progressively smaller.
>
> "The flows of most western rivers, such as the Columbia, Snake, Missouri and Colorado, are depleted by diversions for irrigation. These depletions have not been considered in preparing Table 2 except on the Colorado river, where no entry for the flow is given, but the relative position was based on estimates of the virgin flow (i.e., by adding the depletions for irrigation to the measured flow). In general these depletions would not greatly affect the relative positions of the rivers listed.
>
> "The Mobile river, the eighth ranking river in Table 2, is the name given to the meandering stream, some 38 miles long, which together with a parallel distributary, Tensaw river, carries the combined flow of the Alabama and Tombigbee rivers to Mobile Bay.
>
> "Among the 26 large rivers listed in Table 2, only 9 are independent; that is, the rivers discharge directly into the ocean. The others, such as the Missouri and the Willamette, are tributary to larger streams included in the list. Some rivers, such as the Tennessee, are second-order tributaries, that is, tributary to a tributary of a river that discharges into the ocean. Although it is common practice to follow accepted names in deciding which river is a tributary and which is the main river, it is largely a matter of historical accident which fork carries the name of the lower stream or is separately named.

"The outflow of all streams from the United States into the oceans or across its boundaries totals about 1,800,000 cubic feet per second. Of this total nearly 75 per cent is accounted for by the nine independent streams that appear in Table 1. The remaining 25 per cent is discharged through a host of comparatively minor coastal streams".

The main theme in this circular deals with the "flow" of rivers, a subject I have already mentioned earlier. The first effort to classify rivers on the basis of flow was made in 1880 by Dr. Guppy a British naturalist. It is perhaps natural that man should have devoted much attention and research to this matter when the rivers became more and more important to him for utilization in many respects often of greater importance than mere navigation. A great deal of research work in connection with the amount of flow has been undertaken. But in these researches one finds few remarks on the reason for the difference in the flow and the amount of water at different seasons and their causes. The chief idea has been to try to nail down the heights of full water and low water. Not with the causes which have given rise to the increasing disparities in this respect. For instance,—

"We know only a little about rivers when we measure their lengths, drainage areas, and average flows. There is much to be learned about their range from flood to drought, about their sources, about their chemical quality and about their load of silt and the salts they carry in solution. The topography and climate as well as the vegetation growing in various parts of these river basins greatly affect stream flows and the character of our rivers. All these things must be known if we are to make most effective use of our rivers, large and small. Maps of all kinds, especially topographic maps which show elevations of all streams, mountains and plains, are a valuable aid in studying our rivers".

"From flood to drought" and "about their sources".

These are matters for the Forest Officer to establish and in as near a future as possible show without any doubt that uncontrolled deforestation or removal of a vegetative covering is the chief cause of the irregularity of flow in rivers large and small in different parts of the world.

From the work of L. F. Watts and his associates it is shown that—

"Almost three fourths of the total forest area has been classified as watershed-protection forest, that is, as having major or moderate influence on watershed values. The remaining fourth, because of flat topography or extremely permeable soil or for other reasons, is considered to have slight influence or none. Of the watershed-protection forest about two-thirds, or 308 million acres, exerts a major influence and one-third, or 141 million acres, exerts a moderate influence".

The area of flat topography, etc., may be neglected in the United States. But there are other large areas in the world where the "flat topography", i.e., level lands are subject to as serious erosion and loss of fertility as any experienced in mountain and hilly regions, though from different causes.

The interesting tabular statement entitled "Watershed-Protective Value of Forests in the United States" is given here. It shows the position research work in the matter has reached in the United States and also demonstrates the nature of the information required from so many other parts of the world.

TABLE 1

Watershed-Protective Value of Forests in the United States

Drainage	Total land area	Total forest area	Forest area by watershed-protective influence		
			Major	Moderate	Slight or none
	Thousand acres	Thousand acres	Thousand acres	Thousand acres	Thousand acres
East :					
North-east ..	78,428	42,725	17,320	13,387	12,018
South Atlantic ..	62,812	43,581	29,204	6,412	7,965
East Gulf	105,388	73,313	18,709	4,335	50,269
West Gulf ..	123,926	36,736	2,921	20,678	13,137
St. Lawrence ..	84,616	42,246	5,029	4,112	33,105
Hudson Bay ..	24,960	6,400	66	81	6,253
TOTAL ..	480,130	245,001	73,249	49,005	122,747
Mississippi River Basin :					
Upper Mississippi ..	119,586	28,094	5,694	4,429	17,971
Ohio River ..	130,421	45,391	35,919	7,569	1,903
Missouri River ..	327,447	28,642	20,515	6,769	1,358
Arkansas-Red ..	176,981	52,220	34,560	15,525	2,135
Lower Mississippi ..	33,720	17,854	6,857	1,877	9,120
TOTAL ..	788,155	172,201	103,545	36,169	32,487
West :					
California	70,744	29,780	21,056	3,736	4,988
Colorado	154,880	45,070	36,196	8,829	45
Rio Grande ..	108,160	17,460	14,168	3,292	..
Great Basin ..	138,455	19,534	5,513	12,021	2,000
Columbia	131,119	59,025	38,745	18,180	2,100
Pacific Cascade ..	31,648	26,487	15,564	9,509	1,414
TOTAL ..	635,006	197,356	131,242	55,567	10,547
GRAND TOTAL ..	1,903,291	614,558	308,036	140,741	165,781

Scientifically it may be true to say that it is difficult to draw deductions from the above gross averages since the factors such as forest cover, etc., are controlled by the quantity and distribution of precipitation. But for the practical forester and his work the above Table, or Tables, of its type from other countries, should give him plenty of working scope to commence a counter attack to check the results of man's greed and ignorance in over exploitation. As has been already mentioned earlier the above Table shows that in the Cascade Drainages with steep slopes and heavy rainfall but with about 90% of the total area in forest, mostly dense, floods and erosion are no great cause for concern ; while in the Colorado river basin, with much lower rainfall but with less than one-third of its area in forest of a lighter type, floods and erosion are serious.

The effect of forest destruction on run-off is indicated by studies at the Red Plains Erosion Experiment Station in Oklahoma, where a plot from which the forest litter had been burned produced more than 100 times as much run-off as a similar unburned plot ; its effect on erosion is indicated by a study of Hoyt and Troxell in California, in which the flood flows from burned watersheds were found to contain 20 to 67 per cent of ash and silt.

The Great basin, with only 14 per cent of its area forested and only 28 per cent of this classed as of major influence, developed a serious flood and erosion situation only after the forest and other vegetative cover was reduced by over-grazing and fire. Similarly, in the

Ohio river basin, 35 per cent of which is in forest, the silting problem and increased frequency of floods have followed misuse of the land by man.

It is of interest to remember that although erosion is a geologic phenomenon older than the hills, yet for long periods of time in each region there was a vegetative cover sufficiently dense to protect the soil below and to assist in soil building.

The removal of this ancient cover in the form of destructive fellings of the forest, intensive or prolonged cultivation of virgin grasslands over-grazing, fire, and practices such as shifting cultivation, eventually results in the upsetting of the equilibrium so long maintained.

> "This condition is illustrated by data from an area in Mississippi studied by the Southern Forest Experiment Station where 23 tons of top-soil per acre were lost from cultivated land as compared to only a trace of soil lost from forest land. Erosion cannot be completely stopped, but by restoring forest or other vegetative cover on the steeper and more critical areas the process can be retarded to a rate less than that at which fertility is added to the soil.
>
> "In each of the major drainage basins, bad conditions of stream flow and erosion now exist. On an immence area the forest cover had been reduced or removed by fire and improper grazing methods, and the fertile top-soil has been washed from millions of acres of agricultural lands. The result of this land treatment has been higher and more frequent floods, silted reservoirs and stream channels, accentuated difficulties during periods of low water, and reduced productivity of the land.
>
> "It is said that, for the United States, land ownership, more than any other one factor, has determined the differences in present watershed conditions. The degree to which watershed requirements have been met on land in various types of ownership and the sort of action necessary to establish satisfactory watershed management in each of these types are substantially as follows :
>
> "Agricultural Land, Private—In the eastern half of the United States the most acute stream-flow and erosion problems exist on land now classed as agricultural. On such land, according to rough calculations, perhaps 70 per cent of the erosion takes place and 40 per cent of the water troubles originate. As has been pointed out in the section of this Report entitled "Agricultural Land Available for Forestry" more than 50 million acres of agricultural land in the United States is now abandoned or idle, and present trends indicate the abandonment of an additional 25 or 30 million acres in the next 20 years. Largely because of removal of fertile top-soil often through sheet erosion, the productivity of nearly all the land now abandoned was reduced below the point at which the land could be used economically for crop production.
>
> "Sheet and gully erosion on agricultural land are by no means confined to abandoned land and land approaching abandonment. Under present cropping methods erosion is the usual condition, and unless present practices are remedied more and more of the fertile soil from farm lands generally will be added to the silt load of our streams and rivers. On land suited for agricultural use, the problem is one to be solved by agriculture rather than by forestry".

It may be asked can the Agricultural experts keep the spring water table in the soil at a stable level ? If not it appears to me that it is a forest problem which must come first for solution.

The above would appear to be the present position of the United States on this important watershed or catchment area business.

In a letter written in July in reply to a request for information on watershed areas in South America, William Vogt told me that he had just been engaged on a 5,000 miles trip through the United States, "The purpose of my trip", wrote Vogt,

"Which took me as far west as Colorado, was to give some lectures, and to mak field observations. I had a random sample through some fifteen States and found simply appalling amount of bad land use. I saw literally thousands of miles of row of maize plowed straight up and down hill sides, many of which should not have bee plowed under any circumstances. A notable improvement in plowing was found i a few areas, such as western New York and parts of Iowa and Wisconsin, but by an large there was little indication of progress".

CANADA

Mr. D. A. Macdonald, Dominion Forester, Department of Mines and Resources, gav me some information on the question of the amount of forest on the Catchment Areas of th main rivers and their tributaries as follows :—

"In reply to your question as to the amount of forest still standing on the uppe reaches of the main rivers and their tributaries, I might point out that of the vast are comprising Canada only small fractions are covered by forest inventory. It will b some years yet before an inventory is available of *the productive forest area alone*, whic is estimated at 800,000 square miles. In the circumstances it is impossible to suppl you with information even on a broad general basis.

"With the exception of forest areas which have been deliberately cleared fo agricultural purposes, it is doubtful if any areas exist where the forest at the sourc of a main river has been logged so as to leave a completely denuded area. The genera policy of selective cutting has usually resulted in stands of timber remaining on th area although not necessarily the same species as were exploited.

"For your further information I might point out that the main forest areas o Canada are owned and administered by the individual Province, each of which, wit the exception of Prince Edward Island, maintains its own Provincial Forest Service Some of these are presently engaged in making up their forest inventories, but non have been completed. It is possible that in some specific watersheds a provincia forest service might supply a portion of the information you require. Generall speaking, however, the information for which you ask is not available for Canada as whole, and it will be many years before it is".

Mr. Macdonald referred the questions anent the rivers and tributaries of the countr to the Geographical Bureau of the same Department whose Chief, Mr. F. J. Alcock, provide the following information.

Lengths of Principal Rivers and Tributaries in Canada

NOTE.—In this table the tributaries and sub-tributaries are indicated by indentation of th names. Thus the Ottawa and other rivers are shown as tributary to the St. Lawrence and the Gatineau and other rivers as tributary to the Ottawa.

River	Length in miles
Flowing into the Atlantic Ocean	
Natashkwan (to Labrador boundary)	160
Romaine	270
Moisie	210
Marguerite	130
St. John	399
Miramichi	135

River	Length in miles
St. Lawrence (to head of St. Louis, Minn.)	1,900
Manikuagan	310
Outardes	270
Bersimis	240
Saguenay (to head of Peribonka)	475
Peribonka	280
Mistassini	185
Ashuapmuchuan	165
Chaudiere	120
St. Maurice	325
Mattawin	100
St. Francis	165
Richelieu	210
Ottawa	696
North	70
Rouge	115
North Nation	60
du Lievre	205
Gatineau	240
Coulonge	135
Dumoine	80
South Nation	90
Mississippi	105
Madawaska	130
Petawawa	95
Moira	60
Trent	150
Grand	165
Thames	163
French (to head of Sturgeon)	180
Sturgeon	110
Spanish	153
Mississagi	140
Thessalon	40
Nipigon (to head of Ombabika)	130
Flowing into Hudson Bay	
Hayes	300
Nelson (to Lake Winnipeg)	400
Nelson (to head of Bow)	1,600
Red (to head of Lake Traverse)	355
Red (to head of Sheyenne)	545
Assiniboine	590
Souris	450
Qu'Appelle	270
Winnipeg (to head of Firesteel)	475
English	330
Saskatchewan (to head of Bow)	1,205
North Saskatchewan	760

River	Length in miles
South Saskatchewan (to head of Bow)	865
Bow	315
Belly	180
Red Deer	385
Churchill	1,000
Beaver	305
Kazan	455
Dubawnt	580
Severn (to head of Black Birch)	612
Winisk	295
Attawapiskat	465
Albany (to head of Cat)	610
Moose (to head of Mattagami)	340
Mattagami	275
Abitibi	340
Missinaibi	265
Harricanaw	250
Nettaway (to head of Waswanipi)	400
Waswanipi	190
Rupert	380
Eastmain	510
Fort George	520
Great Whale	365
Leaf	295
Koksook (to head of Kaniapiskau)	660
Kaniapiskau	575
George	365
Flowing into the Pacific Ocean	
Colombia (total)	1,500
Columbia (in Canada)	459
Kootenay	407
Kootenay (in Canada)	276
Fraser	850
Thompson (to head of North Thompson)	304
North Thompson	210
South Thompson (to head of Shuswap)	206
Chilcotin	145
West Road (Blackwater)	141
Nechako	287
Stuart (to head of Driftwood)	258
Porcupine	525
Skeena	360
Bulkley (to head of Maxam Creek)	160
Nass	236
Stikine	236
Alsek	335
Yukon	260
Yukon (mouth to head of Nisutlin)	1,979

River	Length in miles
Yukon (int. boundary to head of Nisutlin)	714
Stewart	320
White	185
Pelly	330
Macmillan	200
Lewes	338
Flowing into the Arctic Ocean	
Anderson	465
Horton	275
Mackenzie (to head of Finlay)	2,514
Peel (to head of Ogilvie)	425
Arctic Red	230
Twitya	200
Liard	755
Fort Nelson	260
South Nahanni	250
Petitot	260
Athabaska	765
Pembina	210
Slave	258
Hay	530
Peace (to head of Finlay)	1,054
Finlay	250
Parsnip	145
Smoky	245
Little Smoky	185
Coppermine	525
Back	605

The various Provinces gave some information of interest and value.

NOVA SCOTIA

Mr. D. A. S. Dyer, Extension Forester, Department of Lands and Forests, in a first communication wrote—

"Regarding your inquiry of chief rivers, etc., in Nova Scotia in relation to the amount of forest area that had been destroyed and what area still remains, I find that it is impossible to reply using the rivers and watersheds as a means of providing our forest area in Nova Scotia". "Very few of our rivers" he says, "are of such a size to be used as a means of transporting forest products and as Nova Scotia is crossed by a network of roads most forest products are transported by this means".

The following, though not within the framework of the inquiry is of interest—

"In Nova Scotia there are eight to ten million acres capable of producing forests. A very small proportion of this area is in virgin timber, over 90% being second growth. Present timber stand is estimated at over six billion board feet, 24% hardwoods with

76% softwoods. Our average annual cut is in excess of 350 million board feet. Ownership of forest land is divided roughly as follows : one-third held by large private owners, one-third in farm woodlots and one-third by the Crown".

Mr. Dyer had to some extent misinterpreted a part of the questionnaire which accounts for some of the above information. In a second letter he expressed regret for misconstruing my enquiry and continued :

"It will still be necessary for me to answer in a very general manner, as no great study has been made of conditions. It was only last year that the first work in this direction was undertaken. In general, one might say that the catchment areas of all our rivers have at one time or another been cut, or destroyed by fire, but a good second growth has been established in many areas. This establishment is due to natural reproduction.

"Erosion is not a major concern in this province, due to the fact that a great part of our province is within the Granite Belt. However, in the northern part, in Cumberland and Colchester County, erosion has taken place due mainly to the depletion of the forest.

"Interruption of water supply is general throughout the province during the summer months, except on those rivers where the flow of water is regulated by dams.

"It is said that the water-table has receded, and this is being borne out by the investigation being carried out into our so-called "Dieback" of Birch".

This is one of the few specific allusions made to the receding water-table that have been stated by Forest Officers in this enquiry.

NEW BRUNSWICK

From the Department of Lands and Mines, Fredericton, some information was received including the more important rivers of New Brunswick and their tributaries. This was provided by Mr. K. B. Brown, Director of Photogrammetry.

In a little booklet entitled "This is New Brunswick" the right note is struck even if the answer is somewhat qualified and tentative. It commences—

"Most of us will agree that New Brunswick is a good place to live. But to be able to live here we must find a way of earning a living. That means that we must produce all we can for our own use and enough surplus to exchange for what we bring in from other places. We depend on the land both for a place to live and for a means of earning a living. Nearly all of us can trace our income back to the land. Our living and that of generations to come depends on how well we use it".

The land area comprises eighteen million acres. There are 32,000 occupied farms containing about 4,000,000 acres. Other people including some large companies own about 6,500,000 acres. The Crown, and that means all the people, own the rest, or, 7,500,000 acres. *Most of this has been leased by the Government to some 300 lumbermen or companies* for forest operations.

This action on the part of many Governments of the past has been a direct cause of the disappearance of forests on a considerable portion of the earth's surface. About 14,000,000 or 80% of the land is forested.

The problem is to reconcile the immediate profit motive which governs forest exploitation with the long term good of the community. It is suggested that the public and Government must equally participate on equal terms in this matter. But in the past it is the Govern-

ments who have shirked this issue, either through their indolence or a fear of an uprising of the people they govern.

Mr. Brown writes—

"There is a very small percentage of waste land in New Brunswick. Approximately 80% is forested, 10% is under cultivation and the remaining 10% of non-forested land is made up of peat bogs, non-reproducing burns, industrial areas of towns, cities, etc.

"All of the areas have been cut over at one time or another but natural reproduction of tree species is usually quick and adequate to restore forest cover. Old fields no longer cultivated soon return naturally to a forested condition".

The list of the more important rivers of the province and their tributaries is as follows :—

St. John River	300 miles in New Brunswick, source in State of Maine, total length 450 miles. Flows into Bay of Fundy
Chief tributaries are :—	
Madawaska River	25 miles long
Green River	40
Iroquois River	25
Quisibis River	25
Grand River	25
Salmon River	35
Tobique River	90
Aroostook River (5 miles in N.B. source in Maine)	100
Meduxnekeag River (15 miles in N.B. source in Maine)	40
Becaquimec River	35
Keswick River	30
Nashwaak River	70
Shogomoc River	20
Eel River	25
Pokiok River	15
Oromocto River	40
Portobello River	20
Grand Lake and Salmon River ..	90
Washademoak River and Canaan River ..	80
Belleisle River	25
Kennebecasis River	75
Nerepia River	30
Restigouche River	100 miles long, flows into Bay of Chaleur then into the Gulf of St. Lawrence
Chief tributaries are :— ..	
Kedgwick River (*source in* Quebec) ..	35 miles long
Patapedia River (source in Quebec) ..	20
Gunamitz River	25
NW. Upsalquitch River	40
SE. Upsalquitch River	50

Miramichi River	150 miles long, flows into the Gulf of St. Lawrence
Chief tributaries are :—	
Bartibog River	30 miles long
NW. Miramichi River	75
Sevogle River	35
Little SW. Miramichi River	60
Renous River	50
Dungarvon River	40
Bartholomew River	40
Barnaby River	35
Cains River	60
River du Vin	30
Petitcodiac River	55 miles long, flows into Bay of Fundy
Chief tributaries are :—	
North River	25 miles long
Pollett River	20
Turtle Creek	20
The following rivers flow into the Bay of Chaleur :—	
Charlo River	50 miles long
Jacquet River	25
Nigadu River	20
Millstream River	20
Tetagouche River	40
Middle River	30
Nipisiquit River	75
Bass River	25
Caraquet River	20
The following rivers flow into the Gulf of St. Lawrence :—	
Pokemouche River	30 miles long
Tracadie River	35
Tabusintac River	40
Kouchibouguac River	30
Kouchibouquaasis River	40
Richibucto River	40
Buctouche River	25
Cocagne River	25
The following rivers flow into the Bay of Fundy :—	
Salmon River	25 miles long
Musquash River	30
Lepresu River	20
Pocologan River	20
Magaguadavic River	50
Digdeguash River	25
St. Croix River	45

It would be of interest to know what proportion of forest exists on the catchment areas of these rivers and their tributaries.

QUEBEC

Mr. Roland Deschamps, Chef du service forestier, forwarded a booklet entitled "Extrait du Rapport du Ministere des Terre et Forets de la Province de Quebec" (1947).

A land classification of the Province shows the following :—

North of 52° latitude—forest lands, 95,000 square miles ; unproductive or denuded, 169,234 ; water, 46,000 square miles ; total 310,234. South of latitude 52°—forest lands, 149,163 square miles ; non-forested (cultivated, destroyed, disforested, eroded, etc.) 20,137 ; unproductive or denuded, 90,000 ; water, 25,000 square miles ; total 284,300 square miles. Total area of the province, 594,534 square miles. This omits the area of the Gulf of St. Lawrence.

The Crown forests amount to 67,518 square miles ; private forests, 26,635 square miles ; disforested lands or with scattered forest, 156,750 square miles ; and agricultural lands, 20,137 square miles ; giving the total land area as above.

Of the above area 67,518 square miles of the Crown forest are devoted to the production of paper pulp and 7,168 square miles of the private forest to the same purpose,—a heavy demand for one product of the forest only.

In his letter dealing with the questionnaire, M. Roland Deschamps says—

"Existing data in our records does not afford us enough information to give you even rough figures along the lines suggested in your letter.

"We are enclosing herewith a small map of the Province to the scale of 20 miles to the inch. Looking at this map, you may see for yourself the vast network of rivers in Quebec area. Quite a large number of these rivers have been only partly surveyed and we hardly have any information on their tributaries. To list only those rivers and tributaries would prove quite a task.

"As to the timbered areas of the basins of these numerous rivers, no inventories have yet been made.

"We have inventory figures of the forested basins adjacent to pulp and paper manufacturing centres, but they do not afford complete data as to lumbered areas, fire destroyed ones and cultivated areas".

In the accompanying Forest Service Report for 1946–47, available only in French, a mine of information is given on the present forestry position in Quebec. But although ahead in some directions of one or two of the other Provinces of Canada, it is apparent from the letter of the Chef du Service that there is a great deal to be done before the Dominion Government have exact information of the actual position of the forests of the country, information which is becoming annually more important.

From the map some of the principal rivers are given here, but except where shown for the whole Dominion as already quoted, no mileage is given for them.

Quebec rivers are as follows :—

St. Lawrence, Ottawa, Harricona, Nottaway, Broadback, Rupert, East Main, Opinaca, du vieux Comptoir, Comb Hills, Grande River, Abchigamich, Petite Baleine, Riviere aux Feuilles, Koksook, George, Duguay, Riviere de la Mort, Hamilton, Riviere aux Outardes. In addition there are a number of small rivers debouching into the Straits of Jacques-Cartier and the Gulf of St. Lawrence,

ONTARIO

Mr. J. F. Sharpe, Division of Timber Management, forwarded to me a brochure on the Forest Resources of Ontario. This was drawn up by himself and J. A. Brodie and published in 1930.

Mr. Sharpe added—

"We are now engaged in a complete new survey of our forest resources which will be completed by about 1952".

The original one of 1930, with the coming and passing of the Second Great World War and the enormous demands it made upon the forests of the world must be much out-of-date now, as Mr. Sharpe pointed out.

"It presents the statistics of forest resources in a fairly clear form although not as you may see by major watersheds".

Therefore, no information on the state of the forests on these is given. There is some interesting information under 'Logging' given in the brochure. It is this form of utilization carried on on so large a scale in the United States and in Canada which has had such disastrous results in some parts of these two countries.

The authors write—

"In the development of the timber trade in Ontario the idea gradually evolved was to dispose of the merchantable timber, principally pine, for cash revenue before handing over the land on which it grew to be converted into farms. The business was not regarded as a permanent industry. At first the system worked well, as many townships in the southern part of the province suited to agriculture were settled by this process.

"As the lumbering operations pressed farther north into the Pre-Cambrian area large areas were placed under license, the soil of which was unsuited for agriculture. The settler, however, continued to follow the lumberman, clearing the land and trying to make farms where the soil conditions indicated that only forests should be grown. Farms were cleared throughout the Ottawa-Huron region which were in many instances abandoned after the transient lumber industry had removed the local market, and the opportunity of winter employment, to regions farther north.

"The high grade timber standards of the early square timber operations left a great deal of inflammable material in the woods, with the resultant fire hazard. In the early part of the nineteenth century this started what proved to be almost a century of periodic forest conflagrations which have been checked only by an efficient system of forest protection. The fact that many of the old pineries have been burned over many times since the lumbering operations, further involves the direct relationship of the present forest resource to the various regulations and practices under which the lumbering operations have from time to time been carried on. Up until 1892 licenses were granted for the cutting of all species of timber on the areas designated. At this time the policy was changed and subsequent licenses reserved spruce, cedar, hemlock, basswood, and other woods to be disposed of otherwise by the Crown. It is doubtful if this regulation had any very far-reaching effect; white and red pine were the marketable species, and most of the other species were left at least for many years on the licensed areas.

"Previous to 1870 the lumbering industry centred mainly in the Ottawa valley, but gradually shifted westward to the Georgian Bay district and in more recent years pressed northward in to the Sudbury region. With the opening up of the markets in Western Canada the industry developed in the Rainy River region.

"Pulpwood operations practically date from 1900, although pulp mills existed in the province from the early settlement days. The expansion of the pulp and paper industry led to the demand for spruce and balsam, species which had been treated hitherto as incidental or ignored altogether in connection with the white pine operations.

"The hardwood industry, dependent on maple, beech, birch and poplar, has been localized up to the present time, due to the limited market and also to the difficulty in floating the logs, which adds to the cost of placing the material on the market.

"The development of the jack pine tie and lumber operations is in response to the large increase of jack pine in the forest as a result of fire".

It would appear to be an urgent piece of work to make a survey of all the catchment areas (watersheds) in the country with a view to ascertaining the amount of forest remaining on them and the amount of erosion, flooding, etc., taking place form deforested areas.

A few of the chief rivers are—St. Lawrence, English river, Severn river, Hayes, Winisk, Ekwan, Attawapistat, Albany, Moose river.

MANITOBA

Agriculture takes preference over Forestry in the province, the wheat exports being all important ! Of a total area of 251,832 square miles in the province, one-fifth to one-sixth is suitable for agriculture. In a report on the Forests of Manitoba issued in 1934 it is stated—

"In the past 20 years annual consumption of wood has risen steadily chiefly because of the phenomenal increase in the demand for newsprint paper, and for the derivatives of wood such as fibre boards and artificial silk".

And this was before the Second World War !

It is said that the extent of the forest resources of the country are not yet fully known. In the early days the visible forest reserves appeared so great, in relation to the demand, that they were considered to be inexhaustable.

This repeats the ideas held at the beginning of last century when the British ruled the Madras Residency and made many demands on the forests which appeared to spread illimitably over the country-side and were considered by the governments of the day to be inexhaustable. By the end of three decades the accessible teak resources in Malabâr had been cut out.

The development in Manitoba, as in other United States and Canadian forests, of the pulp and paper industry on a large scale greatly altered the traditional attitude with regard to the forests and their resources.

Mr. J. G. Somers, Provincial Forester, gave me the following interesting information about the province and its rivers—

"None of the main rivers head in Manitoba, but run through it to Hudson Bay. The heads of the rivers are partly in the prairies and partly in forest regions of the U.S.A. and of other Canadian provinces".

Some of the main tributaries are given below.

The only hill region in Manitoba consists of the elevated region west of an easterly escarpment. The portion of this region known as the Porcupine Hills, the Duck Mountain and the Riding Mountains, the latter a National Park, are still heavily wooded although old timber is being cut to some extent as it reaches maturity. The soil on the greater part of these hills is unsuitable for agriculture but well adapted to the permanent growth of forests.

The characteristic forest of this belt is a mixture of white spruce and aspen. Pure stands of aspen and balsam poplar are also common, probably due to the interference of fire.

With reference to lumbering, Mr. Somers says,—

> "This has not resulted in denuding the area of tree cover in Manitoba at least, except in the case of certain relatively small areas which have been cleared for permanent agriculture. We have no shifting cultivation in the sense which the phrase is used in tropical and sub-tropical countries. Fires have no doubt increased since the white man came, but most areas restock themselves at least sufficiently to prevent erosion".

There is, however, a serious erosion problem in the province, alluded to by Mr. Somers as follows :—

> "We have a serious erosion problem which is slowly but persistently becoming more apparent. This does not, however, pertain to the forest areas proper, but rather to the areas which were originally grasslands, with small groves of aspen in certain regions. The removal of the natural grass cover as a result of cultivation of cereal crops has resulted in considerable wind and water erosion which is showing up on all hilly and rolling areas. Our agricultural authorities are taking steps to prevent this damage, and advise keeping part of these farm lands, more or less permanently seeded down to grass. In other cases, they recommend a long crop rotation cycle, with grass as part of the cycle".

This particular problem is of considerable interest since it corresponds to erosion problems in other parts of the world with considerable level expanses where deserts and dust bowls are in process of forming and increasing in area or perimeter.

Of the main rivers whose catchment areas are outside Manitoba but which flow through the province to their mouths in Hudson Bay are the Churchill, Nelson and Saskatchewan.

Main tributaries with catchment areas in Manitoba are the Seal, North Knife and South Knife, Hayes, Gods river and Berens river.

(*continued*)

STUDIES OF THE DIFFERENTIAL TOXICITY OF HERBICIDES TO TREE SPECIES

BY T. N. SRIVASTAVA

ACKNOWLEDGMENTS

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INTRODUCTION

No one can deny the economic importance of weed control in Agriculture. It is well known that weeds may seriously reduce the yield or even cause total failure of crops, or at least impair their quality and market value. The gain in yield of a cereal crop, as a result of weed elimination, may amount to as high as 227 per cent and even with less severe infestations increases of 50 per cent or more can often be expected (Blackman and Templeman 1936 ; Anon. 1947). In the United States of America alone, it has been estimated that losses due to weeds are of the order of $3,000,000,000 annually (Anon. 1930 ; Wilson 1944).

The various methods of eradication tried in the past, namely, manual, mechanical and burning, however, have not always proved really satisfactory. The discovery of the differential toxicity of certain chemicals to different plant species has, therefore, opened up a new era in methods of weed control. The chemical method is definitely cheaper than those tried so far, and, in view of the increasing cost and shortage of labour after the war, investigations in this field of research are not only important but have become a matter of acute necessity.

As might be expected, researches carreid out so far on the selective toxicity of herbicides have been mostly concerned with agricultural crops, but weed control is also of great importance in forestry and during recent years some promising results in the control of weeds in forest nurseries and regeneration areas have been reported.

Herbicides in general can be of great importance in many other forestry operations such as clearing of fire lines, control of brush in derelict woodlands, eradication of alternate hosts of tree diseases, etc., but, as the reaction in such cases is not always selective, they do not come strictly within the scope of this study.

The primary aim of this study was to investigate the toxicity of various selective herbicides to some economically important tree species, with the object of discovering suitable compounds which might have some application in the practical control of undesirable plants, particularly in forest nurseries and regeneration areas.

PART I

HISTORY OF THE DEVELOPMENT OF SELECTIVE HERBICIDES

The discovery of the selective action of herbicides dates back to 1896, when a French viticulturist, Bonnet, while spraying vines with Bordeaux mixture, noted by chance that any

spray drift coming in contact with the foliage of annual weeds caused a varying degree of injury. He further demonstrated, by spraying a crop of oats with dilute copper sulphate solution, that yellow charlock (*Sinapis arvensis*) growing among the oats could be killed whilst the oats remained undamaged.

Within a year or two of this discovery several other inorganic compounds such as iron sulphate, sulphuric acid, sodium nitrate and ammonium sulphate were reported by various workers to have selective herbicidal properties, but none of these chemicals attracted very much interest until Rabate in 1911 demonstrated the practical advantages to be gained by the use of sulphuric acid as a selective herbicide for cereal crops.

The next important development took place in 1932, when Truffaut and Pastac discovered the selective herbicidal properties of an organic dye-stuff dinitro-ortho-cresol (D.N.O.C.). Both H_2SO_4 and D.N.O.C., however, though found fairly efficient, had certain very great disadvantages in practice such as corrosiveness to skin and clothing and toxicity to human beings. Further investigations in this field led to the introduction of copper chloride, which was found much more active than copper sulphate and was not toxic to human beings nor corrosive to skin and clothes (Blackman 1945 *b* ; 1946 *a & b* ; 1947).

The most important development in this field, however, took place in 1940, when Slade, Templeman and Sexton (1945) discovered that growth substances could also be used as selective herbicides and produced two very useful compounds methyl-chloro-phenoxy-acetic acid (M.C.P.A.) and dichloro-phenoxy-acetic acid (D.C.P.A.). In the same year Templeman and Sexton (1946) discovered another set of organic compounds, the aryl carbamic esters, of which isopropyl-N-phenyl carbamate (I.P.C.) and ethyl-phenyl-carbamate (E.P.C.) showed great promise as selective herbicides and at the present time these compounds are being tested on a large scale.

Other types of compounds which have been found to have selective herbicidal properties are certain petroleum oil fractions. These have recently given some remarkable results in Umbelliferous crops and also in coniferous forest nurseries.

Owing to the importance attached to these different kinds of selective herbicides and the scattered nature of the information concerning them, it is considered worth while discussing the various types in a little more detail.

PROPERTIES OF SOME OF THE MORE IMPORTANT SELECTIVE HERBICIDES

Selective herbicides may be grouped as follows :—

(1) Inorganic compounds.
(2) Organic compounds.
(3) Growth substances, their salts and esters.
(4) Esters of arylcarbamic type.
(5) Oils.

(*1*) *Inorganic compounds.*—The most popular compounds of this series used as selective herbicides are copper salts, iron sulphate and sulphuric acid. Various other compounds such as zinc sulphate, sodium salts, potassium salts, calcium cynamide have also been tried but have not proved of universal application. The greatest drawback with the copper salts and iron sulphate has been their slowness of action and dependence upon the weather. At least 24–48 hours of fine weather are required for their efficient action. Sulphuric acid has the advantage of being very rapid in its action and is also independent of weather, but its corrosiveness to skin, clothes and machinery is the greatest drawback for its widespread use as a herbicide.

Some of the other inorganic compounds which have been used successfully in the eradication of woody plants and killing trees are chlorates, arsenical compounds, carbon bisulphide and borax but they have not so far been found selective in their action. Chlorates or preparations like Atlacide, which contain chlorate, are particularly well known in the eradication of unwanted ground vegetation in regeneration and plantation areas, e.g., heather (in Sweden and Germany), *Lantana* (in India) and *Ribes* spp. (in America). The use of chlorates, however, is usually restricted to areas prior to regeneration since chlorates generally appear to possess no particular selective action but destroy all types of vegetation alike. Ammonium sulphamate has recently been reported as being most effective in killing woody shrubs and trees but again its selective properties are not known.

(*2*) *Organic compounds.*—The most important compounds of this series being used as selective herbicides are dinitro-ortho-cresol (D.N.O.C.) and dinitro-secondary-butyl-phenol (D.N.B.P.). Both are highly toxic and selective. As they have a limited solubility in water, the corresponding sodium and ammonium salts are most commonly used. The sodium salt of D.N.O.C. is sold as a dense suspension in water since the dry product itself is inflammable, but, when the suspension is used as a spray, it is not hazardous on dried vegetation. Both D.N.O.C. and D.N.B.P. are non-corrosive but they are poisonous to insects, animals and human beings. They are effective under the widest latitude of climatic and growth conditions though their action is somewhat limited in cold, foggy or very dry weather. On bright sunny days their action may be quite rapid and leaves may collapse 30 minutes after application. In general 6 to 8 lb. of D.N.O.C. or 3 to 4 lb. of D.N.B.P. in 100 gallons of water is considered to be a suitable rate of application per acre.

(*3*) *Growth Substances.*—The growth substances so far found to be most active as selective herbicides are 2-methyl 4-chloro-phenoxy-acetic acid commonly known as M.C.P.A., 2, 4-dichlorophenoxy-acetic acid (D.C.P.A. or 2, 4-D) and 2, 4, 5-trichloro-phenoxy-acetic acid (2, 4, 5-T or T.C.P.A.). This new class of selective weed killers has several outstanding characteristics, the most important being that they are effective in very minute doses. While chemicals like sodium chlorate and arsenical preparations are effective when applied in large amounts, viz., 1–10% solutions, experiments with M.C.P.A. and D.C.P.A. have shown that these compounds are active at concentrations of approximately ·025 to ·1% (250 to 1,000 p.p.m.), so that, 1 lb. to 2 lb. of the material in 100 gallons of water is considered as a sufficient dosage per acre. The growth substances may be applied either as dusts along with an inert filling material or as a spray in solution. When applied as a dust, 2 cwts. of dusting material containing 2 lb. of chemical per acre has generally been recommended.

Unlike sulphuric acid, copper salts and D.N.O.C. these growth substances are translocated within the body of the plant. Moreover, the growth substances are not dependent upon absorption by the shoots alone ; they can also be absorbed through the roots (Blackman 1945-a), and their action is, therefore, independent of the weather. Compared with other herbicides, however, their effects on plants are very slow and it may take a month or more before the weeds are killed.

Since the acids themselves have a very limited solubility in water, their sodium, ammonium, amine salts and esters are commonly used. (For details of the solubility of the various salts cf. Appendix I).

The esters have been reported to be generally more effective than the amine or sodium salts (Anderson 1947).

T.C.P.A. has recently been reported as being generally more effective on woody plants than the other two compounds mentioned above. *Rubus* spp., which are outstanding among the group of woody plants resistant to 2, 4-D), have been killed by this compound (Barrons *et al* 1947-c ; Dutton 1947 ; Tamm 1947).

Growth substances appear to be highly selective in their action. Marked differences have sometimes been noticed in the sensitivity of closely related plants when treated with with 2, 4-D, e.g., *Plantago lanceolata* is extremely sensitive while *Plantago major* is much less so (Beatty and Jones 1945 ; Marth and Mitchell 1944).

Though these compounds are not toxic to stock or man nor corrosive to machinery or clothing, excessive contact with oily solutions may sometimes cause irritation to the skin and should thus be avoided.

(*4*) *Arylcarbamic Esters.*—The most active compounds of this series recommended for selective herbicidal purposes are Isopropyl-N-phenyl-carbamate (I.P.C.) and Ethyl-phenyl-carbamate (E.P.C.). The most notable characteristic of these compounds is that they have been reported (Templeman and Saxton 1946) as being toxic to most of the cereals and gramineaceous plants but relatively non-toxic to dicotyledonous plants. This is in contrast with the phenoxy-acetic-acids and other herbicides described so far and opens up new aspects in the field of selective weed control. Recent reports from America, however, state that I.P.C. has in general given rather disappointing results in the control of perennial grasses and further investigations are, therefore, necessary before definite conclusions can be drawn.

I.P.C. and E.P.C. have only a limited solubility in water, I.P.C. being soluble only to about 250 p.p.m. at 25°C. It has been found convenient in practice, therefore, to dissolve the I.P.C. in twice its weight of tributylphosphate, the resulting solution being miscible with oil in all proportions (Allard *et al* 1946). It may also be dissolved in other organic solvents such as acetone, alcohol, etc. An average application for the control of grasses is considered to be about 10–20 lb. per acre but more may be required.

(*5*) *Oils.*—The most common oils being used as selective herbicides belong to the petroleum series and it has been found that in general the toxicity of the various fractions increases with boiling point. It appears that the toxicity of these oils is proportional to the amount of unsaturated hydrocarbons and aromatic compounds contained in them. These compounds are removed during refining processes as a result of which the toxicity of the refined oils is reduced.

The different fractions of the oil series have been shown to possess different selectivities as herbicides, viz., gasoline has been recommended for the spot treatment of individual dandelions whereas kerosine containing not more than 4% unsaturates is preferred for dandelions in lawns. If gasoline or any fraction higher than 4% in unsaturates is used, the grass is also injured (Crafts and Reiber 1948).

Oxidation of the oils also reduces their herbicidal activity but oils low in toxicity can be improved by the addition of certain other chemicals known as "fortifying agents". The toxicity of the oils varies with temperature, being higher during hot sunny weather than during cool days. Rain does not reduce their effectiveness to any great extent.

Weed species vary greatly in their response to oil injury. Whilst the Umbelliferæ are notably tolerant and coniferous spp. appear to be fairly resistant, grasses have proved to be most susceptible.

Generally an amount sufficient to wet thoroughly the foliage of the plants is enough for spray applications ; 40 to 100 gallons of oil per acre have been reported as giving good results.

Oils produce two types of toxicity as was first observed by De Ong, Knight and Chamberlain in 1927 with citrus plants.

(*a*) *Acute toxicity.*—In which a rapid burning of the leaves occurs. If the injury is not too great within 24 to 48 hours the plants may recover. This is characteristic of light oils.

(*b*) *Chronic toxicity.*—In this case the action is slow. Symptoms may appear only after several days and consist of a yellow blotching of the leaves followed by a slow death. This kind of toxicity commonly results from oils heavy enough to give the leaves an oil soaked appearance and persistent enough to remain visible on the plants for several days.

PRINCIPLES OF SELECTIVE HERBICIDAL ACTION

Nature of selectivity.—The term "selective herbicide" may be applied to any chemical that will kill one species of plants growing in a mixed crop without injuring another species beyond the point of recovery. The nature of this selective action is not yet fully understood. Morphological and structural differences between different plant species may play an important role, since, for the effective action of a chemical, its penetration in sufficient quantities into the plant tissues is essential. Hence plants having leaves with thick cuticles or waxy surfaces or protected growing points are naturally better protected against attack. There is, however, some evidence that the differential action resulting from morphological characteristics is in some cases modified by differences in the physiological tolerance of the species to the chemical used, e.g., Clovers are less injured by copper sulphate than by iron sulphate although each wets the plants to the same extent. The resistance of young carrots to certain petroleum oils is probably also physiological. They are wetted by the herbicidal spray, which undoubtedly penetrates, but are not appreciably affected, whereas under the same conditions weeds are killed.

Factors controlling the effectiveness of chemicals.—Besides the inherent properties of the plant species, as already described, various environmental factors are known to affect the toxic action of herbicides.

These are as follows.—

1. *The size end age of the plants.*—In general the older the plant, the more difficult it is to kill and the more chemical required, but instances to the contrary have also been reported. For example, Eliason (1949) found that the cotyledons and primary needles of pine seedlings were more resistant than were the mature needles.

Mitchell (1948) has reported that 2, 4-D is translocated from the leaves to other parts of the plant along with carbohydrates and as younger leaves are relatively inefficient in translocation of carbohydrates they may, therefore, be more resistant to the toxic effect of the chemical.

Weaver, Swanson and others (1946) working on certain dicotyledenous plants concluded that older plants were more resistant but that developing floral and ovarial structures were as severely affected as was the young vegetative growth.

2. *Season of spraying.*—While plants in general are most susceptible to herbicidal treatment when young, the best part of the year for spraying perennial plants is in the spring when the plants are in an active stage of growth and food reserves are lowest. At this stage the plants apparently absorb and translocate chemicals most readily. Moreover, some chemicals, 2, 4-D for example, affect physiological processes such as respiration, enzymatic activity, etc., and a chemical which kills by stimulating these processes would theoretically be most effective if applied when these growth processes are most active.

The possibilities of dormant period applications (Barrons *et al*, 1947-b) are also being investigated but as yet no definite conclusions may be drawn.

3. *Growth history of plants in terms of environment.*—Plants grown under optimum conditions are comparatively less resistant than those grown under unfavourable conditions since the former are generally more succulent and tender. Bolley (1908) reported that weeds become more resistant during dry windy weather; under such conditions the plants tend to become woodier, the cuticle thicker and pubescence, in the pubescent species, increased.

4. *Weather conditions at the time of and immediately after spraying.*—Temperature, humidity, rain, fog and dew all have a pronounced effect on the penetration of chemicals into plant tissues and are thus important in the effectiveness of chemicals, but different chemicals vary in their tolerance to adverse weather conditions. A high humidity is essential for success with copper sulphate, iron sulphate and others which penetrate slowly, as otherwise the spray may dry up rapidly and the crystals easily blown away. Aslander (1927) demonstrated that iron sulphate was most effective on mustard plants at 100% relative humidity.

The rate of diffusion of chemicals is directly correlated with temperature. A lethal quantity of a chemical is more likely to penetrate into a plant on warm days than on cool days. Marth and Davis (1945) and Cossit (1948) have shown that higher temperatures were generally associated with a more rapid kill and the latter recommended 60° to 90°F as the most suitable temperature in the use of mineral oils on coniferous beds.

Rain, soon after spraying, generally reduces the effects of the chemical but different chemicals are affected differently.

5. *Relation between concentration and volume of spray applied to a given area.*—This is an important factor in the achievement of best results on an economical scale. Higher concentrations generally penetrate and kill faster and are desirable in unfavourable weather to hasten the killing action, but are not always economical. Smith (1946) found that there was an optimum volume figure below and above which the interception of chemicals declined. He demonstrated a progressive decrease in the magnitude of response below a certain limit of volume: as the volume was reduced a progressively larger amount of 2, 4-D was required for a complete kill. He also found that sprays of relatively larger droplet size were more effective than those of finely atomised particles.

6. *Effects of spray carriers.*—The nature of the carrier or solvent has been shown to affect the killing power of herbicides. Jones (1945) found that with different carriers, different concentrations of 2, 4-D were required to produce the same effect on poison ivy.

7. *Effect of soil.*—Different types of soils have also been found to affect the mortality of plants. Plants in heavy soils for example when treated with chemical sprays have been reported to take twice as long to die as those in lighter soils (Jones, 1945).

8. *Methods of application.*—A considerable variation in the toxicity of chemicals has been observed with different methods of application. Extensive tests with growth substances carried out in America during the war (Anon. 1946) gave widely different results when the same chemical was applied to the soil and to the aerial portions of the plant as a spray, the herbicide being many times more effective in the latter case. Aqueous sprays have been found generally much more effective than the powdered forms.

MODE OF TOXIC ACTION OF HERBICIDES

The knowledge as to how and why a chemical kills plant tissues is, of course, of great importance. It is particularly important in the case of perennial and woody plants since their mortality depends largely on the amount of the chemical translocated to and absorbed by the roots. Various suggestions as to the behaviour of herbicides have been made but no definite information is as yet available.

Inorganic compounds.—Copper salts are supposed to kill by the direct action of copper on the protoplasm whilst iron sulphate is alleged to plasmolyse the cells and disrupt the protoplasm. Acids have been reported to exert a hydrolytic or solvent action upon the constituents of the cell wall and, after penetrating the cell wall, stop protoplasmic streaming and decompose and disorganize the chlorophyll, nucleus and plastids.

Organic compounds.—Little is known about the action of D.N.O.C. and its homologues. They are known to stimulate respiration which may, depending upon concentration, rise to such an extent that photosynthesis cannot keep pace with the loss of dry weight through oxidative processes and death results.

Growth substance.—Growth substances are apparently absorbed by almost any part of the plant. They are known to kill by stimulating physiological processes, viz.

1. Respiration.
2. Enzymic activity.
3. Utilization of reserve carbohydrate and nitrogenous compounds, etc.

The responses are produced either at the point of application or in some cases some distance away from this region. Their effects may be characterised by distorted stem and leaf growth, by inhibition of bud growth and sometimes by the formation of galls on the roots or main stem. If the compound has been absorbed by the roots its distribution to other parts of the plant depends upon the rate of transpiration, but, if the application has been made to the leaves, translocation to other parts takes place along with carbohydrates. Applied to the roots, 2, 4-D has been shown to move to the top of the plant even though a section of the stem has been killed: it moves from the roots up through the stem mainly in the non-living cells of the water conducting system.

Arylcarbamic esters or compounds of the Urethane series.—The first known reference concerning the effect of compounds of the Urethane series on plants is that of Frisen (1929) who worked on the germination of seeds of oats and wheat plants. Since then several other workers, including Templeman and Sexton (1946) have investigated these compounds but no definite conclusions can yet be drawn. It is, however, anticipated that Lefevre's (1939) observations of disorganized mitosis may someday be confirmed.

Oils.—Though the toxicity of oils to plant foliage has been recognized for a long time, the exact mechanism is not yet clearly defined. Tucker (1936) reported that the toxicity of oils was due to the production of asphaltogenic acids as a result of exposure to light and oxygen but this has not been confirmed. Young (1935) reported that oils persist between parenchyma cells for months and concluded that besides toxic substances in the oils, physiological suffocation might also play a great part in the death of the plants. Sweet *et al* (1945) suggested that chronic injury might be due to suffocation of the tissues but that acute injury was due to actual toxicity of the compounds which was correlated with the aromatic content of the oil.

TOXIC RESIDUE OF HERBICIDES IN SOILS

An obvious objection to the use of herbicides is the possibility of toxic residues being left in the soil, but experiments have shown that with the small concentrations of chemicals used generally no deterioration of the soil results and such residues are quickly dissipated. It is still

not known whether the disappearance of the toxic effect is due chiefly to leaching or to other phenomena like biological decomposition, chemical or physical combination with the components of the soil or to all these causes. The effects of various factors have been discussed by Bowser and Newton (1933), Hurd-Karrer (1942), Hauks (1946), Kries (1947), Brown and Mitchell (1948).

Various workers have shown that the inactivation of growth substances in the soil is dependent upon various factors such as soil type, moisture, temperature, the presence of organic matter and soil organisms as well as the amount of chemical applied, the method of application and the type of plant. It has been found (Anon. 1946) that 2, 4-D does not persist in the soil for more than 80 days whilst I.P.C. appeared to disappear within 60 days. Oils on the other hand are generally volatile and as such are removed more quickly from the soil (Cossitt 1947 ; Stoeckler 1948).

Choice and Methods of Application of Herbicides

The choice of a suitable selective herbicide is governed by many factors such as its toxicity to weeds and desirable crop, price, availability, method of application and convenience of handling, etc., but as far as the sprays are concerned the most important considerations are the availability of suitable spray machinery and the relation of the environmental factors to the action of the chemical.

Methods of application of herbicides.—These may be broadly classified into three groups :—

(*1*) *Pre-planting treatment.*—The treatments of the soil with a chemical prior to sowing or planting of the crop to eliminate seeds and vegetative parts of the weedy plants involved in propagation.

(*2*) *Pre-crop-emergence treatment.*—The control of weeds prior to the emergence of seedlings of the main crop or prior to the emergence of the foliage from buds in bulbs or twigs.

(*3*) *Post-emergence treatment.*—This treatment is applied after both the weeds and the main crop have emerged and occur as a mixed population.

So far as applications of these methods to forestry are concerned, methods 1 and 2 show great promise in nurseries and deserve extensive investigations. Method 3 has a wider application and can, for example, be applied in other silvicultural operations, viz., protection and development of the young growth in regeneration and plantation areas, improvements of grazing grounds, etc.

Chemical Methods of Killing Undesirable Woody Shrubs and Trees

These may be grouped as below :—

(1) Felling or cutting the trees and then either treating the stumps or the sprouts.

(2) Placing chemicals in cups, frills or holes made in the tree trunk or girdling the trees and applying pastes or concentrated solution of chemicals. (Allan 1918 ; Swabley 1937 ; Anon 1943 ; Peevy 1947 and 1948).

(3) Pouring solutions into a soil basin around the plants or injecting poisons into the main roots of seedlings near the root collar (Anderson 1945 ; Campbell and Peevy 1945).

(4) Foliage sprays.

(5) Spraying stems of young saplings with or without cutting the bark.

(6) Application of chemicals to the soil in nurseries.

Methods 1 to 3 are not necessarily based on the selective properties of herbicides and hence will not be discussed in detail.

With spraying there is the question of suitable spray machinery. For experimental or small scale spraying, hand pumps may serve the purpose but for large scale operations, suitable power sprays mounted on tractors and similar vehicles have to be improvised. Recently, aeroplanes have been employed in America for spraying agricultural fields but the operation has proved too expensive.

In some cases where foliage sprays have been ineffective, cutting the canes and trunks, and spraying and applying chemicals to cut surfaces appears to give an effective kill, but the reduction in the amount of surface to which the chemical can be applied probably necessitates the use of much higher concentrations of the herbicide. Sufficient data are not yet available to support a definite recommendation for the general application of this technique.

The possibilities of controlling woody plants in the sapling stage by spraying the uncut bark of the stems have also been investigated and fair success has been reported (Barrons *et al* 1947-a and 1947-b ; Baranek and Paul 1947 ; Day 1947-b). For this type of treatment oils have been recommended as carriers for the herbicides. Presumably the oil aids in the penetrating of the chemical but no kill is expected after a mature corky bark has developed.

ERRATA TO C. F. C. BEESON'S (1941) BOOK: "*THE ECOLOGY AND CONTROL OF THE FOREST INSECTS OF INDIA AND THE NEIGHBOURING COUNTRIES*"

I—INTRODUCTION

Beeson's book*, first published in 1941, which has been out of print for the last few years, is in demand by the students of the Indian Forest Colleges, by professional entomologists and by many libraries. Efforts are being made to reprint it, but these may take considerable time to be realised.

Meanwhile, old copies will continue to be used for some considerable time to come.

As a result of the constant use of the book by the members of the Branch of Forest Entomology at the Forest Research Institute, Dehra Dun, many errors, totalling slightly over 200, have come to our notice ; some are trivial, others of a more serious nature. This list of *errata* is being published in the belief that it will be useful to other entomological workers and forest officers. Its publication may also stimulate fellow readers to collect their own additional *errata*. The Forest Entomologist will be grateful to those who would care to send in such additions, so that they may be consolidated and published for general information. The entire list will then be used for correction when the book is reprinted or revised in the future.

The preparation of this list of *errata* has been the co-operative effort of practically all the technical members of the Branch of Forest Entomology, particular help being received from the following : Balwant Singh, G. D. Bhasin, P. N. Chatterjee, R. N. Mathur and G. D. Pant. Useful help was also received from B. M. Bhatia, an ex-member of this Branch. The *errata* given in Beeson's book itself on pages 2–3 have also been incorporated in the present list.

Forest Research Institute,
Dehra Dun.

M. L. ROONWAL,
Forest Entomologist.

II—ERRATA
to
Beeson's *The Ecology and Control of the Forest Insects of India, etc.* (1941)

NOTE.—The counting of lines normally begins from the top of a page but excludes the page-heading. When the counting begins from below, this fact is indicated besides the line number.

1. Page 2, line 22 : *Delete* "p. 81 1.25, *Millettia* not *Milltetia* ;". (This is incorrect *erratum* in Beeson's book).
2. Page 2, lines 24 and 25 : *For* "myrmecophilus" *read* "myrmecophilous".
3. Page 2, lines 2 and 3, from below : Beeson, on p. 2, gives the following *erratum*, without indicating its place of insertion : "p. 316, The true Cantharidæ are not described in this book". It should perhaps be inserted on page 316, line 25 after "instars".
4. Page 3, line 15 : *For* "p. 715" *read* "p. 795".
5. Page 6, line 15 : *For* "apply" *read* "amply".
6. Page 24, line 24 : *For* "synynomous" *read* "synonymous".

* Beeson, C. F. C. 1941. *The Ecology and Control of the Forest Insects of India and the Neighbouring Countries, pp. 6 + ii* + 1007.—Dehra Dun (Vasant Press).

7. Page 39, lines 7 and 8 : *For* "**Ptinidæ** *read* "**Anobiidæ** (**Ptinidæ**)". [The two **Anobiidæ**" families are the same, Anobiidæ being the current name adopted. Beeson himself does not deal with Ptinidæ separately.]
8. Page 40, line 9 : *For* "and" *read* "und".
9. Page 40, line 11 : *For* "ANOBIIDÆ" *read* "ANOBIIDÆ (**Ptinidæ**)". [This follows from the *erratum* mentioned above under p. 39, lines 7 and 8].
10. Page 47, line 14 : *For* "*Stephygyne*" *read* "*Stephegyne*".
11. Page 47, line 17 : *For* "*tumbuggiana*" *read* "*tumbuggaia*".
12. Page 47, line 25 : *For* "**Disphaeroma**" *read* "**Disphaerona**".
13. Page 47, line 30 : *For* "*Milletia*" *read* "*Millettia*".
14. Page 47, line 31 : *For* "*cordata*" *read* "*cordatus*".
15. Page 47, line 1, from below : *For* "*Gerardinia*" *read* "*Girardinia*".
16. Page 48, line 17, from below : *For* "*longipetiolatum*" *read* "*longepetiolatum*".
17. Page 48, line 20, from below : *For* "**cinereomaculata**" *read* "**cinereomaculatus**".
18. Page 49, line 8, from below : *For* "**Tropideres**" *read* "**Tropiderinus**".
19. Page 57, line 16 : *For* "than" *read* "then".
20. Page 66, line 13 : *For* "keepng" *read* "keeping".
21. Page 68, line 7, from below : *For* "*Heterobstrychus*" *read* "*Heterobostrychus*".
22. Page 83, line 15, from below : *For* "*Hertiera*" *read* "*Heritiera*".
23. Page 85, line 5, from below : *For* "*Xylopyra*" *read* "*Xylopyrus*".
24. Page 90, line 3, from below : *For* "*Xylopyra*" *read* "*Xylopyrus*".
25. Page 95, line 16, from below : *For* "*Xylopyra*" *read* "*Xylopyrus*".
26. Page 98, line 11 : *For* "mymecophilous" *read* "myrmecophilous".
27. Page 98, line 11 : *For* "agressors" *read* "aggressors".
28. Page 98, line 24 : *For* "more less" *read* "more or less".
29. Page 98, line 15, from below : *For* "Agressors" *read* "Aggressors".
30. Page 102, line 6 : *For* "agressive" *read* "aggressive".
31. Page 104, line 1 : *For* "*Jonthoceras*" *read* "*Jonthocerus*".
32. Page 110, line 11 : *For* "*Ipomoea*" *read* "*Ipomaea*".
33. Page 117, line 2 : *For* "*Chikrassia*" *read* "*Chickrassia*".
34. Page 117, line 11 : *For* "*Chikrassia*" *read* "*Chickrassia*".
35. Page 117, line 16, from below : *For* "*Holoptelia*" *read* "*Holoptelea*".
36. Page 128, line 12, from below : *Delete* "from".
37. Page 130, line 10 : *For* "dumbell" *read* "dumb-bell".
38. Page 133, line 13, from below : *For* "thismeans" *read* "this means".
39. Page 136, line 1, from below : *For* "matnre" *read* "mature".
40. Page 145, line 11 : *For* "*Mitragyne*" *read* "*Mitragyna*".
41. Page 152, line 13, from below : *For* "XIII, i, p. 52" *read* "XIII, ii, p. 22".
42. Page 155, line 22, from below : *For* "**chloridolium**" *read* "**chloridolum**".
43. Page 156, line 7, from below : *For* "*Mitragyne*" *read* "*Mitragyna*".
44. Page 157, line 22, from below : *For* "*fraxinifolia*" *read* "*fraxinifolius*".
45. Page 158, line 6 : *For* "*fraxinifolia*" *read* "*fraxinifolius*".

46. Page 159, line 2 : *For* "**Cyriopalpus**" *read* "**Cyriopalus**".
47. Page 160, line 21, from below : *For* "*Mallotns*" *read* "*Mallotus*".
48. Page 164, line 7, from below : *For* "tunelling" *read* "tunnelling".
49. Page 177, line 15, from below : *For* "tbe" *read* "the".
50. Page 188, line 5, from below : *For* "**Nothorrhina**" *read* "**Nothorhina**".
51. Page 201, line 9, from below : *For* "larva" *read* "beetle".
52. Page 202, line 17 : *For* "*Milletia*" *read* "*Millettia*".
53. Page 212, line 19, from below : *For* "*Litsea*" *read* "*Litsœa*".
54. Page 218, line 1, from below : *Add* "is" *after* "species".
55. Page 221, line 11 : *For* "*Poinciania*" *read* "*Poinciana*".
56. Page 221, line 18 : *For* "*Ipomoea*" *read* "*Ipomœa*".
57. Page 228, line 3, from below : *Delete* "*Prunus armeniaca*".
58. Page 228, line 4, from below : *After* "*serrata*" *add* "*Prunus armeniaca*".
59. Page 230, line 14 : *For* "clyindrical" *read* "cylindrical".
60. Page 231, line 8, from below : *For* "*Necollyris*" *read* "*Neocollyris*".
61. Page 237, line 5, from below : *For* "**Psuedoclerops**" *read* "**Pseudoclerops**".
62. Page 248, line 13, from below : *For* "**Pseudobothrides**" *read* "**Pseudobothrideres**".
63. Page 252, line 1, from below : *For* "*Plagio-*" *read* "*Pagio-*".
64. Page 253, line 7, from below : *For* "India" *read* "Indian".
65. Page 258, line 4 : *For* "**Anisus**" *read* "**Anius**".
66. Page 261, line 23 : *For* "*Mo us*" *read* "*Morus*".
67. Page 261, line 2, from below : *for* "*glomeratus*" *read* "*glomerata*".
68. Page 266, line 4 : *For* "*Anisus*" *read* "*Anius*".
69. Page 279, line 2 : *For* "*nerifolium*" *read* "*neriifolium*".
70. Page 279, line 5 : *For* "*Litsea*" *read* "*Litsœa*".
71. Page 284, line 15 : *For* "developes" *read* "develops".
72. Page 294, line 8, from below : *For* "*roxburgianus*" *read* "*roxburghianus*".
73. Page 314, line 12, from below : *For* "preceeding" *read* "preceding".
74. Page 317, line 23 : *For* "**Cantharis rouxi** and **C. tenuicollis**" *read* "**Decapotama** (or **Psalydolytta**) **rouxi** and **D.** (or **P.**) **tenuicollis**".
75. Page 317, line 11, from below : *For* "**chicorii**" *read* "**cichorii**".
76. Page 325, line 16 : *For* "found" *read* "find".
77. Page 329, line 18, from below : *For* "*Q. semicarpifolia*" *read* "*Q. semecarpifolia*".
78. Page 336, line 2 : *For* "*rcbusta*" *read* "*robusta*".
79. Page 367, line 15 : *For* "part n" *read* "part in".
80. Page 373, line 8 : *For* "**Dryocoetus**" *read* "**Dryocoetes**".
81. Page 373, line 24 : *For* "*Exoecaria*" *read* "*Excœcaria*".
82. Page 377, line 22, from below : *For* "**Lepicerinus**" *read* "**Leperisinus**".
83. Page 390, line 19 : *For* "*ferra*" *read* "*ferrea*".
84. Page 394, line 9, from below : *For* "*litoralis*" *read* "*littoralis*".
85. Page 394, line 10, from below : *For* "*Exoecaria*" *read* "*Excœcaria*".
86. Page 402, line 11 : *For* "*acuminatus*" *read* "*acuminata*".

87. Page 438, line 3 : *For* "**Gasterophilus**" *read* "**Gastrophilus**".
88. Page 445, lines 3 and 4, from below : *Delete* "*Bombotelia jocosatrix*".
89. Page 445, line 4, from below : *After* "*puera*" *add* "(Hyblæidæ), *Bombotelia jocosatrix*".
90. Page 447, line 14 : *Delete* "," *after* "*stola*" and *add* "(Noctuidæ),".
91. Page 447, line 14 : *Delete* "(Noctuidæ)" *after* "*balteata*".
92. Page 452, line 10, from below : *For* "(Pyralidæ)" *read* "(Noctuidæ)".
93. Page 453, line 17, from below : *Delete* "(Pyralidæ)".
94. Page 453, line 17, from below : *Delete* "," *after* "*carbonifera*" and *add* "(Pyralidæ),".
95. Page 454, last line of Fig. 132 : *After* "Below, Sturmia inconspicuella, 6–9 mm." *add* "The hind legs do not show the essential characters of Sturmia".
96. Page 459, line 7 : *For* "*Cephnodes*" *read* "*Cephonodes*".
97. Page 459, line 15, from below : *After* "*subapicalis*" *add* "*Thiacidas postica*".
98. Page 459, line 17, from below : *Transfer* ", *Cavira* [after correcting it as *Caviria*] *ochripes*" *between* "*nuda*" *and* "(Lymantriidæ)".
99. Page 459, line 18, from below : *Delete* "*Thiacidas postica*".
100. Page 470, line 21 : *For* "feeds" *read* "feed".
101. Page 484, last line : *After* "*insulana*" *add* "(Noctuidæ)".
102. Page 488, page-heading : *For* "CAHLCID" *read* "CHALCID".
103. Page 488, line 17 : *Delete* "," *after* "*puera*" and *add* "(Hyblæidæ)".
104. Page 498, line 10, from below : *For* "(Noctuidæ)" *read* "(Blastobasidæ)".
105. Page 499, line 4, from below : *For* "it" *read* "is".
106. Page 505, line 4, from below : *For* "**C. bimarginatus**" *read* "**Calliephialtes bimarginatus**".
107. Page 508, lines 15 and 16 : *For* "*Hyb aea*" *read* "*Hyblaea*".
108. Page 530, line 4 : *For* "in found" *read* "is found".
109. Page 536, line 8, from below : *For* "ro" *read* "of".
110. Page 539, line 19, from below : *For* "XXII" *read* "XX".
111. Page 587, line 5, from below : *For* "**E. pychnochroa**" *read* "**E. pycnochra**".
112. Page 599, line 10 : *For* "pp. 560" *read* "pp. 565".
113. Page 599, line 4, from below : *For* "**Orsonobia**" *read* "**Orsonoba**".
114. Page 602, line 21, from below : *For* "**Statmopoda**" *read* "**Stathmopoda**"
115. Page 607, line 21 : *For* "overcrowed" *read* "overcrowded".
116. Page 615, line 2 : *For* "*Stereospermun*" *read* "*Stereospermum*".
117. Page 619, line 3, from below : *For* "p. 293" *read* "p. 295".
118. Page 619, line 14, from below : *For* "pp. 293, 294" *read* "pp. 295, 296".
119. Page 619, line 18, from below : *For* "pp. 252, 294" *read* "pp. 255, 295".
120. Page 620, line 11 : *For* "p. 293" *read* "p. 295".
121. Page 641, line 20 : *For* "**Stilponita**" *read* "**Stilpnotia**".
122. Page 643, line 18 : *For* "pp. 252–296" *read* "pp. 253–298".
123. Page 643, line 7, from below : *For* "p. 278" *read* "p. 280".
124. Page 643, line 17, from below : *For* "p. 281" *read* "p. 282".
125. Page 644, line 3 : *For* "p. 264" *read* "p. 265".
126. Page 644, line 5 : *For* "p. 264" *read* "p. 265".
127. Page 644, line 8 : *For* "p. 292" *read* "p. 294".

128. Page 644, line 19 : *For* "p. 265" *read* "p. 266".
129. Page 645, line 9, from below : *For* "p. 265" *read* "p. 266".
130. Page 646, line 2 : *For* "p. 272" *read* "p. 274".
131. Page 646, line 4 : *For* "p. 272" *read* "p. 274".
132. Page 646, line 9 : *For* "p. 273" *read* "p. 275".
133. Page 646, line 16 : *For* "p. 287" *read* "p. 288".
134. Page 646, line 23 : *For* "p. 287" *read* "p. 288".
135. Page 646, line 26 : *For* "p. 287" *read* "p. 289".
136. Page 646, line 33 : *For* "p. 286" *read* "p. 288".
137. Page 646, line 6, from below : *For* "p. 282" *read* "p. 283".
138. Page 646, line 9, from below : *For* "p. 281" *read* "p. 283".
139. Page 647, line 8 : *For* "p. 285" *read* "p. 287".
140. Page 647, line 18 : *For* "pp. 280" *read* "p. 281".
141. Page 647, last line : *For* "p. 264" *read* "p. 265".
142. Page 647, line 5, from below : *For* "**Dipthera**" *read* "**Diphthera**".
143. Page 647, line 11, from below : *For* "p. 279" *read* "p. 281".
144. Page 648, line 6 : *For* "p. 276" *read* "p. 278".
145. Page 648, line 25 : *For* "p. 240" *read* "p. 292".
146. Page 649, line 9, from below : *For* "p. 271" *read* "p. 272".
147. Page 649, line 15, from below : *For* "p. 271" *read* "p. 272".
148. Page 650, line 5 : *For* "p. 265" *read* "p. 266".
149. Page 650, line 7 : *For* "p. 265" *read* "p. 266".
150. Page 650, line 12 : *For* "p. 288" *read* "p. 290".
151. Page 651, line 6, from below : *For* "p. 292" *read* "p. 294".
152. Page 651, line 11, from below : *For* "p. 291" *read* "p. 293".
153. Page 651, line 25, from below : *For* "p. 273" *read* "p. 274".
154. Page 652, line 4 : *For* "p. 288" *read* "p. 289".
155. Page 652, line 17 : *For* "p. 274" *read* "p. 275".
156. Page 652, line 13, from below : *For* "p. 277" *read* "p. 278".
157. Page 653, line 3 : *For* "p. 288" *read* "p. 290".
158. Page 653, line 21 : *For* "p. 289" *read* "p. 291".
159. Page 653, line 12, from below : *For* "p. 284" *read* "p. 286".
160. Page 653, line 18, from below : *For* "p. 282" *read* "p. 284".
161. Page 654, line 7 : *For* "p. 284" *read* "p. 286".
162. Page 656, last line : *For* "p. 280" *read* "p. 282".
163. Page 657, line 4, from below : *For* "p. 291" *read* "p. 292".
164. Page 658, line 18, from below : *For* "p. 276" *read* "p. 277".
165. Page 665, line 6 : *For* "(fig. 157, No. 15)" *read* "(fig. 156, No. 14)".
166. Page 670, line 16, from below : *Delete* "the whole line".
167. Page 680, line 2, from below : *For* "the" *read* "he".
168. Page 693, line 5, from below : *For* "**Trachylepidea**" *read* "**Trachylepidia**".
169. Page 705, page-heading : *For* "THYRID LEP" *read* "TORTR LEP".

170. Page 737, line 8, from below : *For* "**Cosmocarta**" *read* "**Cosmoscarta**".
171. Page 776, lines 1–3 from below : *After* "Fig. 193", *delete* "Stem of a....previously killed" and *add* "Oxyrachis tarandus, Nos. 1, 2, 3, egg-slits in twig of Albizzia lebbek and egg enlarged. Nos. 4–9, details of head and abdomen (genitalia) of adult".
172. Page 781, line 14, from below : Close the bracket.
173. Page 789, line 8 : *For* "Fig. 194" *read* "Fig. 195".
174. Page 789, line 10 : *After* "wingless" *read* "or have rudimentary wings".
175. Page 790, line 1 : *For* "fig. 194" *read* "fig. 195".
176. Page 790, line 7, from below : *For* "fig. 194" *read* " fig. 195".
177. Page 795, line 25 : *For* "in the face of" *read* "apart from".
178. Page 795, line 26 : *After* "**biotic potential**". *add* "(**Biotic potential** is a definite characteristic of a species independent of environmental resistance)." [See Beeson's *errata*, p. 3, lines 16–18.]
179. Page 796, line 11 : *After* "Life-cycle :" *add* " (see p. 24 for the meaning of life-cycle)".
180. Page 802, line 20, from below : *After* "it bores" *read* "as well as its water of metabolism".
181. Page 812, line 18 : *For* "avilable" *read* "available".
182. Page 814, line 10 : *For* "polyghagous" *read* "polyphagous".
183. Page 820, line 12 : *For* "suicidal" *read* "internecine".
184. Page 825, line 12 ; from below : *For* "enthusiastic-lovers" *read* "enthusiastic bird-lovers".
185. Page 848, line 21 : *For* "resistance of" *read* "resistance to".
186. Page 872, line 11 : *For* "compell" *read* "compel".
187. Page 873, lines 4 and 5 : *For* "is entirely dependent on dead wood" *read* "flourishes where shelter-tunnels are easily made".
188. Page 877, line 23 : *For* "b nding" *read* "binding".
189. Page 879, line 2, from below : *For* "teacupfull" *read* "teacupful".
190. Page 893, line 12 : *For* "Panels-made" *read* "Panels made".
191. Page 922, line 23 : *For* "3/4rs" *read* "3/4ths".
192. Page 933, line 19 : *Insert* "wood," *after* "in".
193. Page 936, line 7 : *After* "floor" *delete* the comma.
194. Page 957, line 16, from below : *After* "parasites" *read* "*e.g.*".
195. Page 958, line 8 : *For* "p. 591" *read* "p. 598".
196. Page 961, in Fig. 203 : *Delete* the arrows joining "predators" and "parasites" of "puera".
197. Page 968, line 11 : *For* "hiberated" *read* "hibernated".
198. Page 985, line 22 : *For* "or" *read* "for".
199. Page 993, third row, line 6 : *For* "Cantharis" *read* "Decapotama" and transfer to p. 995.
200. Page 995, third row, line 3 : *For* "Cyriopalpus" *read* "Cyriopalus".
201. Page 996, second row, line 7 : *For* "Disphaeroma" *read* "Disphaerona".
202. Page 997, third row, line 18 : *For* "Gasterophilus" *read* "Gastrophilus".
203. Page 999, second row, line 9, from below : *For* "Lepicerinus" *read* "Leperisinus".
204. Page 1001, third row, line 19 : *For* "Orsonobia" *read* "Orsonoba".
205. Page 1005, first row, line 21 : *For* "597" *read* "697".
206. Page 1005, second row, line 8 : *For* "Stilponita" *read* "Stilpnotia".

THE HIMALAYAN CONIFERS II

The Ecology of humus in conifer forests of the Kulu Himalayas

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PART II

(*Continued from the* Indian Forester, *January 1951, page 63*)

SUMMARY

Soil profiles on river alluvia from the chir pine, blue pine, blue pine-deodar communities, and on glacial moraines and alluvia from spruce and silver fir communities were studied from the Parbatti and Kulu valleys. The data show a significant correlation between organic matter, nitrogen and Ca content of the humus. Both nitrogen and CaO tend to increase with an increase in organic matter in these soils. The amounts of organic matter, and nitrogen falls considerably in lower layers of the soil.

On the basis of pH, nitrogen, organic matter, and Ca the soils studied have been classed into three categories of skeletal, brown earth and podsolized soils and these three types have been found to bear different forest communities. pH of the soil also shows relationship with forest communities. Broadly speaking spruce and silver fir communities occurring at higher altitudes are found on brown earth soils of low pH value, high organic matter, high nitrogen and high amounts of Ca. The blue pine-deodar and deodar occurring in medium altitudes are found on podsolized or old brown earth profiles with medium pH values, low Ca, medium N and medium organic matter content. The *chir* pine community occuring on lowest altitudes occupies skeletal soils with high pH, low organic matter, low nitrogen and medium calcium. The high amounts of nitrogen and organic matter in soils at higher altitudes is probably due to low temperature and high amounts of atmospheric moisture under which conditions the decomposition of plant material in soils is inhibited. On the basis of C/N and CaO content of tree litter of conifer and broad-leaved species growing in these forests explanations have been given for differences in pH and calcium content of these soils.

Some remarks have been offered on the problem of conifer regeneration in this area and the necessity of intensive work on management types of Suri has been stressed for this purpose.

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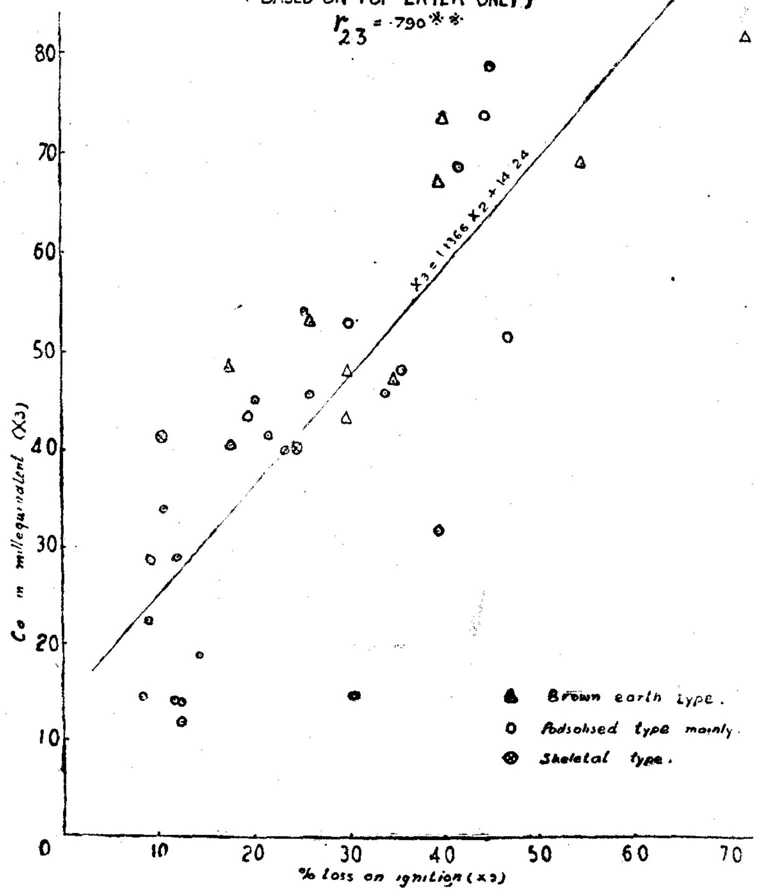
REGRESSION OF Ca IN MILLEQUIVALENT ON% LOSS ON IGNITION
(BASED ON TOP LAYER ONLY)

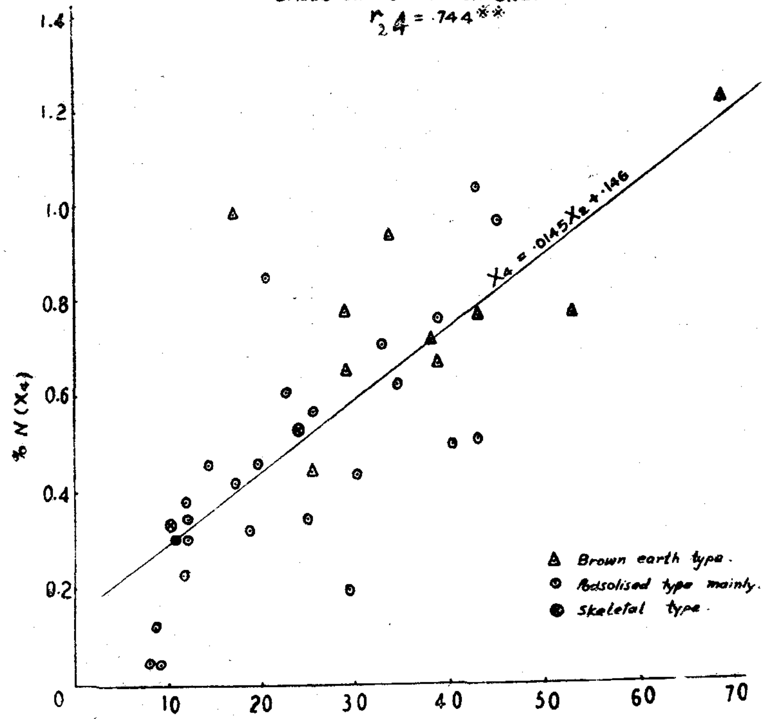


GRAPH 3

REGRESSION OF % N ON % LOSS ON IGNITION

BASED ON TOP LAYER ONLY

$r_{24} = \cdot 744^{**}$

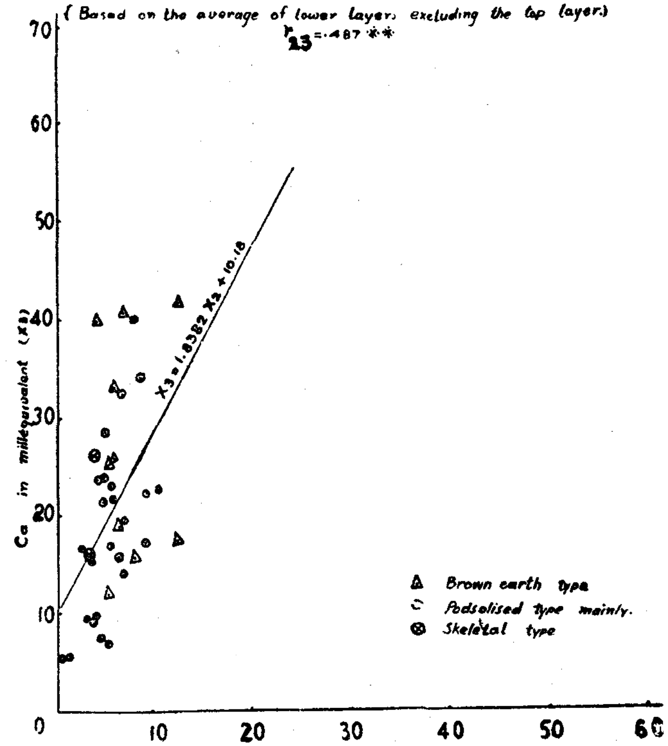


GRAPH II

REGRESSION OF Ca IN MILLEQUIVALENT ON % LOSS ON IGNITION

(Based on the average of lower layers excluding the top layer)

$r_{23} = \cdot 487^{**}$



GRAPH III

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APPENDIX

Pro-file No.	Locality	Geological horizon	Depth in inches	pH	Ca in mili-equi-valent	% Loss on igni-tion	% N.	Number of trees within 15 feet of the pit their girth in inches, and regeneration
	(1) Deodar community							
1	Kasol C R/4	Old river alluvium	0	7·7	14·8	8·3	0·04	A recent opening in the forest.
			2	6·5	31·1	15·0	0·19	
			3½	6·3	23·4	8·0	..	Blue pine regeneration.
			14	6·2	12·0	4·2	..	
2	1/9 Khobas CI(c)	,,	0	6·4	45·6	25·9	0·56	Opening in deodar forest.
			3	6·2	13·1	5·8	0·12	
			6	5·8	11·6	4·6	..	
			36	5·8	2·8	0·5	..	
3	1/9 Khobas CI(c)	,,	0	6·7	40·0	23·0	0·60	Edge of deodar forest.
			6	5·8	9·0	4·0	0·06	
			18	5·4	10·0	4·0	..	Deodar and blue pine regeneration.
			24	5·3	7·6	3·9	..	
			36	5·2	11·0	3·8	..	
4	R/4 Kasol CII	,,	0	5·8	46·0	33·3	0·70	Deodar 5 trees, girth 18, 26, 28, 42, 49.
			2	6·3	33·2	15·4	0·16	
			7	6·3	12·0	5·6	..	
5	R/4 Kasol CII	,,	0	6·4	51·6	46·0	0·95	Deodar 4 trees, girth 31, 32, 56, 60.
			3	5·2	26·0	6·0	0·05	
			8	5·5	30·0	6·6	..	Deodar regeneration.
			24	6·1	12·8	4·6	..	
8	R/4 Kasol CII	,,	0	6·4	43·6	19·1	0·31	Deodar 4 trees, girth 60, 65, 70, 73.
			3	6·4	27·2	5·9	0·06	
			18	6·5	9·2	8·0	..	
			30	6·2	5·6	6·5	..	

(*contd.*)

APPENDIX—(*contd.*)

Pro-file No.	Locality	Geological horizon	Depth in inches	pH	Ca in mili-equi-valent	% Loss on igni-tion	% N.	Number of trees within 15 feet of the pit their girth in inches, and regeneration
9	R/4 Kasol CII	Old river alluvium	0 3 18	6·1 6·0 6·0	32·0 12·4 22·0	39·4 6·0 11·9	0·75 0·09 ..	Deodar 3 trees, girth 31, 44, 58.
14	Kanwar III ..	River alluvium	0 1 10 36	6·3 6·4 6·3 6·3	14·2 10·4 4·4 1·8	12·3 1·7 0·7 0·3	0·34 0·05	Deodar 5 trees, girth 58, 65, 76, 78, 80.
26	R/6 Bindraban CI	,,	0 8 18 24 36	6·4 6·2 6·0 5·7 5·7	74·0 28·0 26·6 21·6 18·8	43·6 5·9 4·2 2·8 4·7	0·50 0·01	Deodar 10 trees, girth 17, 22, 24, 26, 27, 28, 31, 32, 32, 36.
27	R/6 Bindraban CI	,,	0 1½ 6 18 24 36	6·1 7·0 7·1 7·0 6·8 6·8	68·6 98·7 25·6 30·0 20·0 25·0	40·6 13·9 6·6 8·6 4·7 6·3	0·49 0·01	Deodar 6, girth 29, 32, 34, 35, 45, 46.
28	R/6 Bindraban CI	,,	0 6 18 24 36	6·7 6·7 6·6 6·5 6·4	54·0 18·0 20·4 24·4 22·9	25·4 5·7 5·3 4·1 7·2	0·33 0·11	Deodar 6 saplings.
29	R/6 Bindraban CI	,,	0 4 6 18 24 36	6·3 6·3 6·10 6·7 6·5 6·3	41·8 28·2 20·4 13·6 17·4 5·0	21·2 8·8 4·4 3·6 6·1 3·7	0·84 0·05	Opening in deodar forest. Blue pine regeneration.
30	Jari Ban 1/15 CI	,,	0 6 12 18 24 26	6·3 6·3 6·2 5·6 5·3 5·6	40·8 22·4 24·2 23·6 23·2 25·0	17·5 4·9 4·2 4·9 4·3 4·3	0·41 0·10	Deodar 2, girth 56, 57.
31	Jari Ban 1/15 CI	,,	0 4 12 24 30	6·0 6·0 5·9 5·9 6·1	29·0 27·2 28·8 27·3 30·0	12·0 4·3 5·3 5·4 4·9	0·38 0·09	A wide open gap in deodar forest.
32	Jari Ban 1/15 CI*	,,	0 4 12 24 30	6·1 7·0 8·0 8·2 8·4	25·6 74·4 74·2 75·6 69·6	6·2 5·8 5·2 4·9 4·5	0·22 0·06	Opening in deodar forest.
33	Jari Ban 1/15 CI	,,	0 6 18 24 36	6·8 6·5 6·3 6·6 6·7	22·5 18·0 19·2 22·0 25·4	9·0 5·8 2·1 7·5 3·6	0·12 0·08	Opening in deodar forest.

* Samples marked with an asterisk were not included in statistical analysis; as they were either from burnt area or contained bits of lime-stone, the origin of which was uncertain and unnatural according to our present state of knowledge.

(*contd.*)

APPENDIX—(*contd.*)

Profile No.	Locality	Geological horizon	Depth in inches	pH	Ca in miliequivalent	% Loss on ignition	% N.	Number of trees within 15 feet of the pit their girth in inches, and regeneration
40	R/2 Monalgarh	River alluvium	0 3½ 6 18 36	6·8 6·7 6·7 6·0 6·0	34·0 34·6 24·6 36·6 32·0	10·8 9·8 2·8 8·0 5·3	0·30 0·15	Deodar 4, girth 49, 52, 61, 66.
41	R/2 Monalgarh	„	0 4½ 9 18 36	6·1 6·1 5·9 5·7 5·7	28·8 26·0 34·4 37·6 37·0	9·3 5·3 9·7 8·8 10·9	0·04 0·14	Deodar 4, girth 31, 60, 77, 98.
6	(2) *Deodar-kail community* R/4 Kasol CII	„	0 1 12 15	6·2 6·20 6·30 6·40	45·2 30·8 10·0 7·0	20·0 9·8 5·9 3·0	0·45 0·07	Deodar 3, girth 69, 70, 84. Kail 2, girth 56, 57.
7	R/4 Kasol CII	„	0 2 5 12 27	6·4 6·3 6·3 6·3 6·5	53·0 30·0 32·0 10·0 6·0	29·8 8·9 7·7 6·8 3·4	0·19 0·07	Deodar 2, girth 56, 87. Kail 1, girth 8.
10	1/9 Khobas CI*a*	River alluvium sandy and bouldery	0 ¾ 6 18 36	6·5 6·4 6·3 6·3 6·2	19·0 16·0 11·0 7·0 3·0	14·5 10·4 0·1 2·7 0·2	0·45 0·33	Deodar 1, girth 42. Kail 4, girth 21, 27, 36, 36. Deodar felled, regeneration of kail.
11	(3) *Kail community* 1/9 Khobas CI*a*	„	0 1 9	6·4 6·4 6·3	12·0 9·0 6·0	12·4 8·7 0·1	0·30 0·22 ..	Kail 4, girth 60, 63, 64, 70. with *Rhododendron.*
12	1/9 Khobas CI*a*	„	0 1 14 36	6·4 6·2 6·0 6·10	14·4 10·2 4·0 1·9	12·0 0·6 0·1 0·1	0·23 0·03	Kail 3, girth 53, 64, 72. Deodar regeneration.
13	1/9 Khobas CI*a*	„	0 1 7 36	6·7 6·1 6·1 5·9	15·0 13·8 5·2 2·0	30·4 14·7 0·5 0·05	0·43 0·35	Kail 1, girth 70. Deodar regeneration.
38	R/5 Somachalaon CII	River alluvium with boulders at 13″ sandy	0 12 18 24 36	6·8 6·6 6·2 6·1 6·2	48·4 18·4 20·6 14·6 12·0	35·0 3·5 3·1 2·3 2·4	0·61 0·06	Kail 5, girth 34, 38, 45, 48, 58.
39	R/5 Somachalaon CII	River alluvium with sand and boulders	0 3½ 12 18 24 36	6·5 6·8 6·9 6·9 6·9 6·8	78·8 38·4 15·5 8·0 5·3 8·6	43·9 12·0 1·9 1·5 0·5 1·3	1·02 0·05	Kail 2, girth 44, 52. Deodar regeneration, open forest previously felled.

(*contd.*)

APPENDIX—(*contd.*)

Profile No.	Locality	Geological horizon	Depth in inches	pH	Ca in mili-equivalent	% Loss on ignition	% N.	Number of trees within 15 feet of the pit their girth in inches, and regeneration
	(4) *Chir pine-kail community*							
34	1/11 Dunkra Muil CI	River alluvium entire profile boulders	0	6·5	40·0	24·3	0·52	Chir pine 2, girth 33 63. Kail 1, girth 46. Kail regeneration.
			12	6·4	22·2	6·4	0·09	
			18	6·1	11·2	2·2	..	
			24	6·1	14·5	2·4	..	
			36	6·0	14·7	2·5	..	
	(5) *Chir pine community*							
35	1/11 Dunkra Muil CI	Alluvium full of boulders	0*	6·2	56·8	37·8	0·77	Chir pine 2, girth 54, 62. This area had been burnt as evidenced by the occurrence of charcoal at 4″ depth and black soil on the surface.
			1*	6·3	38·7	16·4	0·09	
			4*	6·4	51·4	17·1	..	
			12	6·6	18·9	8·3	..	
			18	6·8	17·4	4·6	..	
			24	6·8	15·2	6·1	..	
			36	6·7	25·0	6·7	..	
36	1/11 Dunkra Muil CI	Scree slope of sandy composition	0*	7·0	48·6	18·0	0·10	Chir pine 3, girth 12, 49, 51.
			12	6·6	22·4	6·2	0·03	
			18	6·6	21·4	5·6	..	Chir pine regeneration.
			24	6·5	18·6	4·4	..	
			36	7·3	25·2	9·7	..	
37	1/11 Dunkra Muil CI	,,	0	7·3	41·2	10·4	0·33	Chir pine 2, girth 40, 48.
			6	7·2	28·2	5·4	0·12	
			12	7·0	22·1	3·1	..	
			24	6·8	26·0	3·9	..	
			36	6·8	27·0	3·6	..	
	(6) *Spruce community*							
16	Pulga 1/6 Kalga C2	River alluvium	0	6·2	53·3	25·9	0·44	Opening in a spruce kail forest with spruce regeneration, one deodar seedling also present.
			1	5·6	25·1	5·5	0·10	
			6	5·7	21·1	4·4	..	
			12	5·7	25·7	6·0	..	
			18	5·8	28·0	6·0	..	
17	Pulga 1/6 Kalga C2	Alluvium with some morainic material and boulders	3	6·4	48·5	17·5	0·98	Spruce 6, girth 56, 62, 76, 101, 104. 3 saplings of Silver fir and Silver fir seedlings.
			3½	6·1	76·0	4·1	0·15	
			15	6·4	22·6	4·4	..	
			24	6·1	29·0	4·5	..	
			36	5·7	31·2	3·9	..	
18	Pulga 1/6 Kalga C2	Moraine with big boulders at 24″	0	5·6	48·0	29·7	0·65	Spruce 2, girth 42, 110. Spruce regeneration.
			2	5·9	32·6	7·0	0·06	
			18	5·6	34·6	6·9	..	
			36	5·5	30·2	4·0	..	
19	Pulga 1/6 Kalga C2	Moraine with big boulders at 18″	0	5·2	43·4	29·7	0·77	Spruce 1, girth 42. Silver fir regeneration.
			6	5·6	28·2	6·6	0·06	
			18	5·2	27·4	5·9	..	
			24	5·3	23·4	2·0	..	
			36	5·2	21·6	8·3	..	

* Samples marked with an asterisk were not included in statistical analysis; as they were either from burnt area or contained bits of lime-stone, the origin of which was uncertain and unnatural according to our present state of knowledge.

(*contd.*)

APPENDIX—(*concld.*)

Profile No.	Locality	Geological horizon	Depth in inches	pH	Ca in mili-equivalent	% Loss on ignition	% N.	Number of trees within 15 feet of the pit their girth in inches, and regeneration
	(7) *Silver fir community*							
20	Pulga 2/6 Bhandag CII	Moraine clayey brown	0	6·5	73·8	39·1	0·66	Silver fir 7, girth 86, 94, 107, 124, 130, 156.
			6	6·6	38·6	6·3	0·03	
			12	6·0	42·0	7·3	..	
			18	5·5	36·2	8·0	..	
			24	5·3	46·6	6·3	..	
			36	5·2	37·6	7·1	..	
21	Pulga 2/6 Bhandag CII	,,	0	5·6	69·5	53·4	0·76	Opening in fir forest.
			3½	5·7	43·9	17·4	0·46	Silver fir regeneration.
			8	5·5	39·3	10·0	..	Evidence of previous burn.
			24	5·3	40·5	10·2	..	
22	Pulga 2/6 Bhandag CII	Moraine clayey brown sandstone at 9″ and 24″	0	6·0	94·0	43·6	0·76	Silver fir 4, girth 60, 72, 94 and 106.
			7	6·2	24·9	29·5	0·04	
			24	5·9	13·5	3·6	..	Silver fir regeneration.
			36	5·7	15·4	3·2	..	
23	Pulga 2/6 Bhandag CII	Moraine clayey brown sandstone at 24″	0	5·9	67·1	38·7	0·71	Silver fir 3, girth 126, 136, 168.
			3½	6·1	39·9	21·3	0·54	
			9	5·9	12·7	5·1	..	Silver fir regeneration.
			24	5·7	10·9	3·4	..	
			36	5·8	0·2	2·0	..	
24	Pulga 2/6 Bhandag CII	Moraine clayey brown sandstone at 18″	0	5·9	47·5	34·2	0·92	Opening in forest, silver fir regeneration.
			12	5·4	18·0	5·5	0·02	
			24	5·2	19·1	7·0	..	
			36	5·1	20·0	6·2	..	
25	Pulga 2/6 Bhandag CII	Moraine clayey brown sandstone at 24″	0	5·5	82·0	69·7	1·20	Silver fir 4, girth 89, 115, 129, 135.
			9	5·5	18·4	6·6	0·02	
			24	5·3	9·6	4·3	..	Silver fir regeneration.
			36	5·2	8·0	4·4	..	

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*b*) (Analytical Method)

(Continued from the "Indian Forester", *January 1951, page 54)*

Design for a timber bridge of span 40 feet, width 10 feet to take I.R.C. 'B' class loading, timber used being Sal (*Shorea robusta*). Grade of timber being structural No. 2 conforming to Standard grade.

(A) Design of (1) Decking,
(2) Roadbearers,
(3) Transoms, etc.

remain the same as that for a 40 feet timber 'through bridge' of Howe type as calculated in Part V(*a*) Graphical Method.

In the following pages design of a 40 feet Howe 'through bridge' by analytical method will be discussed.

(B) Design of 40 feet span Howe Truss :—

ANALYTICAL METHOD :

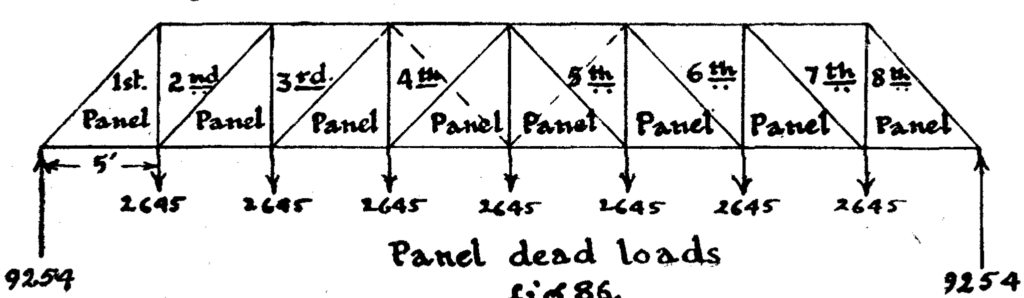
Introduction.—

(1) Let L = Span of bridge, divided into 8 bays
= 40 feet ; each panel length = 5 feet
D = Height of Truss = $\frac{1}{8}$ of span
= 5 feet.

(2) Dead load on the truss including
(*a*) one truss load,
and (*b*) half superstructure load
as calculated from the assumed sizes in the graphical method Part V(*a*) is equal to 9 tons. [Refer Appendix I, Part V(*a*)] = 20160 lb. (say)

This total distributed dead load is divided into 8 panels ; hence panel dead load at each joint is

$$\frac{20160}{8} = 2645 \text{ lb. say. See Fig. 86.}$$



Panel dead loads
Fig 86.

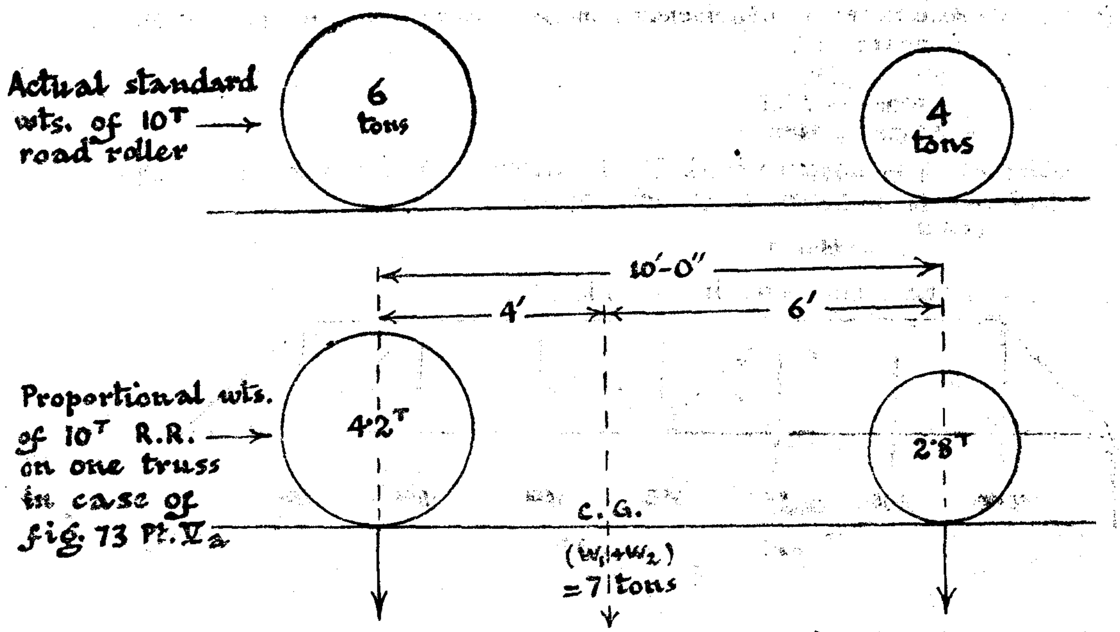


fig. 86 a.

(3) The live load over one truss consists of

(*a*) point load of 7 tons [because of 10-ton standard road roller scraping past a wheel guard as per Fig. 73 Part V(*a*)]

plus (*b*) half U.D.D.L. of 0·34 ton per linear foot of span for each traffic lane, (as per I.R.C. 'B' class loading)

$$= \frac{1}{2}\,\frac{0 \cdot 34}{1}\,\frac{40'}{1} = 6 \cdot 8 \text{ tons} = 7 \text{ tons (say).}$$

Note.—Half of 0·34 ton is considered, because the loading is considered on one truss instead of two trusses.

(4) The 7 tons point load in (3*a*) is roughly* equivalent to a E.U.D.D.L. of 13 tons to give a little more than the B.M. due to a two axle wheeled traffic such as a 10-ton road roller on the bridge. (Refer Appendix III).

* Actually in case of wheeled loads (e.g., Road Roller), the formulæ for equivalent uniformly distributed dead load per ft. run of bridge is $w = 2\,\frac{(W_1 + W_2)(L - x)}{L^2}$ ....(Refer Appendix III)

where $(W_1 + W_2)$ in our case = 7 tons (see Fig. 73, Pt. V*a*)
x = distance of C.G. of $(W_1 + W_2)$ from load W_1
= 4 feet (see Fig. 2, Appendix III)
L = span of Bridge = 40 feet

$$\therefore\ wL = 2\,\frac{(W_1 + W_2)(L - x)}{L}$$

∴ E.U.D.D.L. over whole bridge of 40 feet $= 2\,\frac{(7)(40 - 4)}{40}$
= 12·6 Tons
= 13 Tons (say).

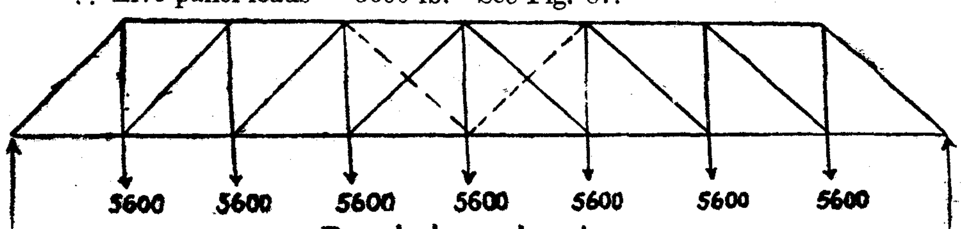
(5) ∴ Live load in terms of equivalent uniformly distributed dead load over whole span of one truss is

$\therefore = (4) + (3)b$
$= 13 \text{ tons} + 7 \text{ tons}$
$= 20 \text{ tons} = 44800 \text{ lb.}$

This live load in terms of E.U.D.D.L. is divided into 8 panels ; hence panel dead load due to live load at each joint is

$$\frac{44800}{8} = 5600 \text{ lb.}$$

∴ Live panel loads = 5600 lb. See Fig. 87.

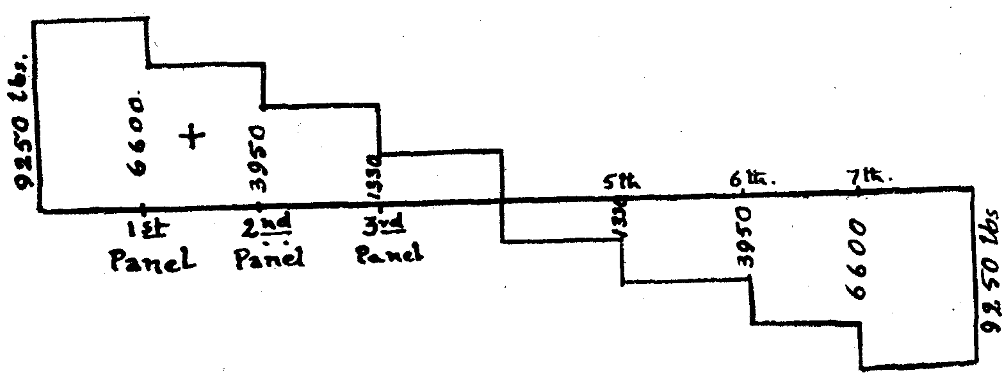


Panel live loads
Fig 87.

(C) Consideration of dead load shears in the truss, i.e., shears in the truss due to panel dead loads of 2645 lb. at each bottom joint :—(Fig. 86).

(1) The dead load reaction $= \frac{1}{2}$ (No. of node points $\times$ 2645)
$= \frac{1}{2} (7 \times 2645)$
$= 9254$ lb. (say) Fig. 86
$= 9 \cdot 25$ in thousands of lb.

(2) The dead load shears are—[considering all joints from the left reaction (Fig. 86), and assuming all forces upwards +tive ; and all forces downwards —tive] See Fig. 88



S.F. Diagram for Panel dead loads
fig. 88.

In the 1st panel, shear $V_1 = +9 \cdot 25$.............. Writing in thousands of lb.

„ 2nd „ „ $V_2 = +9 \cdot 25 - 2 \cdot 65$

$= +6 \cdot 60$.............. „ „ „

„ 3rd „ „ $V_3 = 9 \cdot 25 - 2 \cdot 65 - 2 \cdot 65$

$= +3 \cdot 95$.............. „ „ „

„ 4th „ „ $V_4 = 9 \cdot 25 - (3 \times 2 \cdot 65)$

$= +1 \cdot 30$.............. „ „ „

„ 5th „ „ $V_5 = 9 \cdot 25 - (4 \times 2 \cdot 65)$

$= -1 \cdot 30$.............. „ „ „

„ 6th „ „ $V_6 = 9 \cdot 25 - (5 \times 2 \cdot 65)$

$= -3 \cdot 95$.............. „ „ „

„ 7th „ „ $V_7 = 9 \cdot 25 - (6 \times 2 \cdot 65)$

$= -6 \cdot 60$.............. „ „ „

(D) Determination of stresses in different parts of bottom boom (or top boom) in the Howe truss due to panel dead loads :—

(1) *Rule 1.*—(See Appendix IV). The stress in any chord member (either bottom or top) is equal to the product of the algebric sum of the shears in the panels up to that section (i.e., node point), starting from the left support, and the tangent of the angle which the diagonals make with the vertical

i.e., $S_{x_d} = V_d \times \tan \phi$.

where S_{xd} = Stress in chord x due to panel dead loads.

V_d = Sum of dead load shears in the panels up to that section (or node point) under consideration.

ϕ = Angle made by diagonals with the verticles.

(2) Chord stresses (bottom boom) due to panel dead loads in case of our bridge as per the above rule are :—See Fig. 89.

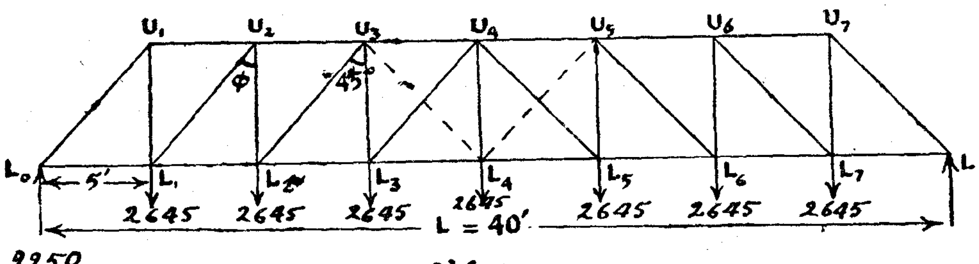


Fig. 89.

Referring Fig. 88

for member $L_0 L_1$;

stress $= +9 \cdot 25 \tan 45° = +9 \cdot 25$.................. in thousands of lb.

for member $L_1 L_2$;

stress $= (9 \cdot 25 + 6 \cdot 60)\ 1 = +15 \cdot 85$.............. „ „

for member $L_2 L_3$;

stress $= (+9 \cdot 25 + 6 \cdot 60 + 3 \cdot 95)\ 1 = +19 \cdot 80$...... „ „

for member $L_3 L_4$;
stress $= (+9 \cdot 25 + 6 \cdot 60 + 3 \cdot 95 + 1 \cdot 30) \times 1$
$= +21 \cdot 10$ .... in thousands of lb.

for member $L_4 L_5$;
stress $= (+9 \cdot 25 + 6 \cdot 60 + 3 \cdot 95 + 1 \cdot 30 - 1 \cdot 30) \times 1$
$= +19 \cdot 80$ .... " "

for member $L_5 L_6$;
stress $= (+9 \cdot 25 + 6 \cdot 60 + 3 \cdot 95 + 1 \cdot 30 - 1 \cdot 30 - 3 \cdot 95)\ 1$
$= +15 \cdot 85$ .... " "

for member $L_6 L_7$;
stress $= (+9 \cdot 25 + 6 \cdot 60 + 3 \cdot 95 + 1 \cdot 30 - 1 \cdot 30$
$- 3 \cdot 95 - 6 \cdot 60)\ 1 = +9 \cdot 29$ .... " "

Note.—(*a*) Plus sign (+) of the stresses in members of bottom boom indicates that members are in tension.

(*b*) Similarly —tive sign of the stresses in the members of top boom will indicate that members are in compression.

(*c*) The above assumptions of signs for nature of loads (stresses) will be proved in Part V(*c*) stress diag. method.

(E) Determination of stresses in different parts of top boom in the Howe Truss due to panel dead loads :—

Rule (*2*).—First prove that the stresses (forces) in the chords of bottom boom are equal to stresses (forces) in the corresponding chords of the top boom.

After this rewrite the stresses in chords of top boom equal to the already found out [calculated as per page 133 para (D)2] stresses in chords of bottom boom.

Method for proving (E) (*Rule 2*).

(1) A simple method is to pass a section, cutting

(i) The member whose stress is required and

(ii) As few other members as possible.

(2) Now equate the algebric sum of the horizontal forces to zero to find the stress in the member desired.

Example.—To find the stress in chord $U_1 U_2$ of the top boom (Fig. 90).

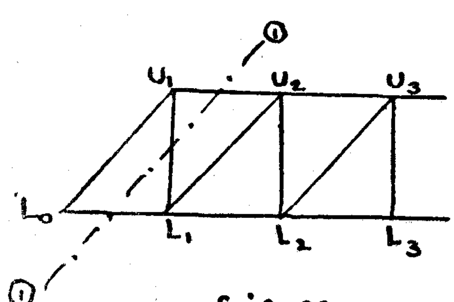


Fig. 90.

Method :

(1) Pass a section 1—1 cutting

(i) the member $U_1 U_2$ whose stress is required

and (ii) also cutting the members $U_1 L_1$ and $L_0 L_1$ (i.e., as few other members as possible).

(2) The only horizontal forces cut by the section 1—1 are the stresses in $U_1 U_2$ and $L_0 L_1$.

Equating them to zero gives

$+$ stress in $U_1 U_2$ $+$ stress in $L_0 L_1 = 0$

$\therefore$ stress in $L_0 L_1 = -$ stress in $U_1 U_2$.

Note.—(1) $U_1 U_2$ is taken $-$tive because top boom is in compression.

(2) $L_0 L_1$ is taken $+$tive because bottom boom is in tension.

(3) Our assumption in the graphical method on page 40 under explanation of Fig. 76 para J(4) regarding relation of stresses in members of top and bottom boom is thus proved here, i.e.

(3) Rewriting E(2)

Bottom boom (tension)		Relation of	Top boom (compression)	
stress in chord $L_0 L_1$	$=$	$-$ stress in chord	$U_1 U_2$	$= -$ 9250 lb.
,, ,, ,, $L_1 L_2$	$=$	$-$,, ,, ,,	$U_2 U_3$	$= -$ 15850 lb.
,, ,, ,, $L_2 L_3$	$=$	$-$,, ,, ,,	$U_3 U_4$	$= -$ 19800 lb.
,, ,, ,, $L_3 L_4$	$=$	(no corresponding top chord)		....
,, ,, ,, $L_8 L_7$	$=$	$-$ stress in chord	$U_7 U_6$	$= -$ 9250 lb.
,, ,, ,, $L_7 L_6$	$=$	$-$,, ,, ,,	$U_6 U_5$	$= -$ 15850 lb.
,, ,, ,, $L_6 L_5$	$=$	$-$,, ,, ,,	$U_5 U_4$	$= -$ 19800 lb.

(F) Determination of stresses in diagonals of the Howe Truss due to panel Dead Loads :—

(1) In this truss it is assumed that diagonals will always carry compression under dead loads. (This will be proved in Part V(*c*), stress diag. method).

(2) (*a*) We had seen under panel dead loads (Fig 86), positive (+) shear is developed in the left half of the Howe Truss (Fig. 88).

(*b*) And negative shears in the right half of the Howe Truss (Fig. 88).

(3) (*a*) Similarly positive shears due to live load (i.e., E.U.D.D.L.) will produce compressive stresses in the diagonals of the left half of the truss.

(*b*) Similarly negative shears due to live load will produce tensile stresses in the diagonals of the left half of the truss.

(*c*) Similarly negative shears due to live load in the right half of the truss will indicate compression in the diagonals of the right half of the truss.

(*d*) And positive shears due to live load in the right half of the truss will indicate tension in the diagonals of the right half of the truss.

(4) *Rule* (*3*) (see Appendix V).—The stress in a diagonal is given by the product of the shear at the section (a—a) which cut the diagonal and the secant of the angle the diagonal makes with the vertical (Fig. 91).

i.e., V_s sec ϕ = stress in the diagonal.

where V_s = shear at the section (a—a) cutting the diagonal whose stress is required.

ϕ = angle the diagonal makes with the vertical.

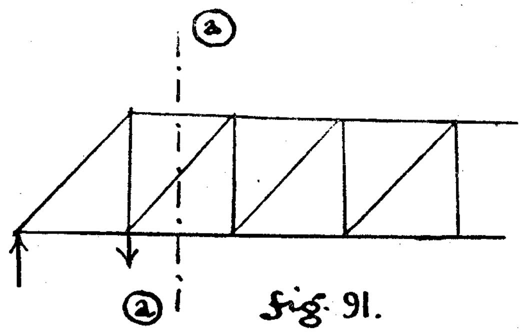


Fig. 91.

(5) Hence the stress in the diagonals of the Howe truss due to panel dead loads are

$L_8 U_7 = L_0 U_1 = - 9 \cdot 25 \sec \phi = - 9 \cdot 25 \; 1 \cdot 415$ (because $\sec \phi = \sec 45° = \sqrt{2} = (1 \cdot 415)$

$= - 13 \cdot 09$ in thousands of lb.

$L_7 U_6 = L_1 U_2 = - 6 \cdot 60 \; 1 \cdot 415 = - 9 \cdot 34$,, ,, ,, ,,

$L_6 U_5 = L_2 U_3 = - 3 \cdot 95 \; 1 \cdot 415 = - 5 \cdot 59$,, ,, ,, ,,

$L_5 U_4 = L_3 U_4 = - 1 \cdot 30 \; 1 \cdot 415 = - 1 \cdot 84$,, ,, ,, ,,

Note.—Negative sign of the stresses indicate that all members of the diagonals are in compression.

(G) Determination of stresses in the verticals of the Howe truss due to panel dead loads :—

(1) *Rule* (*4*).—Stresses in the vertical is the shear at the section cutting the vertical.

i.e., $S_V = V_S$

where S_V = stress in the vertical

V_S = shear at the section cutting the vertical.

Note.—The above equation is similar to one used for finding stress in a diagonal, viz., stress in a diagonal = V_S sec ϕ.

But in case of stress in vertical member, angle ϕ which the member (whose stress is to be found, i.e., vertical member) makes with the vertical is zero. (i.e., sec 0° = 1).

(2) Hence stresses in the verticals of the Howe truss due to panel dead loads only can be found as follows :—

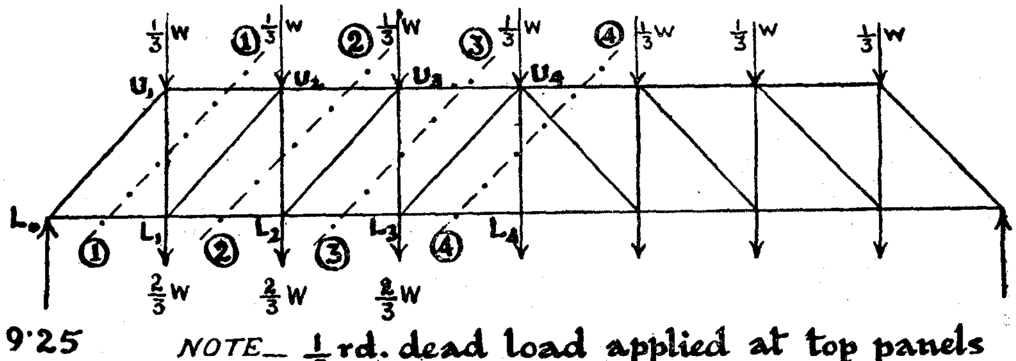
(*a*) To find stress in vertical $U_1 L_1$ (Fig. 92)

$\therefore \; S_{U_1L_1} = V_{1-1} \sec \phi$

$\therefore \; S_{U_1L_1} = + 8 \cdot 37$ sec zero

$= + 8 \cdot 37 \times 1$

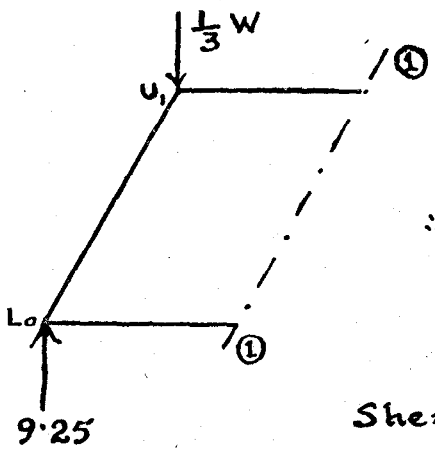
$= + 8 \cdot 37$ in thousands of lb.



NOTE— $\frac{1}{3}$rd. dead load applied at top panels
$\frac{2}{3}$rd. dead load applied at bottom panels
W is 2·64 in thousands of lbs. (dead load)

Fig. 92.

Note.—It will be noted that (Fig. 93)



$V_{1-1} = +9{\cdot}25 - \frac{1}{3} \times 2{\cdot}64$
$= +8{\cdot}37$ in thousands of lbs.
$\therefore S_{U_1L_1} =$ 8370 lbs.

Shear at section 1-1.

Fig. 93.

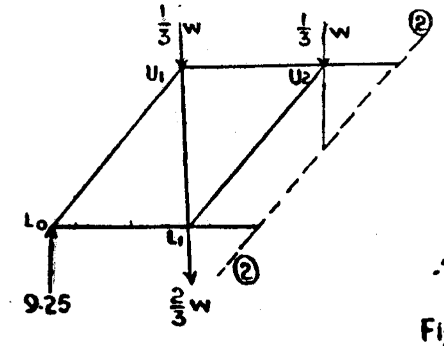
$$
\begin{aligned}
V_{1-1} = \text{shear at section 1–1} &= +9\cdot25 - \tfrac{1}{3}\,W \\
&= +9\cdot25 - \tfrac{1}{3} \times 2\cdot64 \\
&= 9\cdot25 - 0\cdot88 \\
&= +8\cdot37 \text{ in thousands of lb.} \\
&= 8370 \text{ lb.}
\end{aligned}
$$

(*b*) To find stress in vertical U_2L_2 (Fig. 92)

$\therefore\ S_{U_2L_2} = V_{2-2} = +5\cdot73$ in thousands of lb.

Note.—It will be noted that (Fig. 94)

$$
\begin{aligned}
V_{2-2} = \text{shear at section 2–2} &= +9\cdot25 - \frac{2}{3} \times \frac{2\cdot64}{1} - \frac{2}{1}\left(\frac{1}{3} \times \frac{2\cdot64}{1}\right) \\
&= 9\cdot25 - 3\cdot52 \\
&= +5\cdot73 \text{ in thousands of lb.} \\
&= 5730 \text{ lb.}
\end{aligned}
$$



$$V_{2\text{-}2} = +9.25 - \tfrac{2}{3}W - \tfrac{1}{3}W - \tfrac{1}{3}W$$
$$= +9.25 - \tfrac{2}{3} \times \tfrac{2.64}{1} - \tfrac{1}{3} \times \tfrac{2.64}{1} - \tfrac{1}{3} \times \tfrac{2.64}{1}$$
$$= +9.25 - 3.52$$
$$= 5.73 \text{ in thousands of lbs}$$
$$\therefore S_{U_2L_2} = 5730 \text{ lbs.}$$

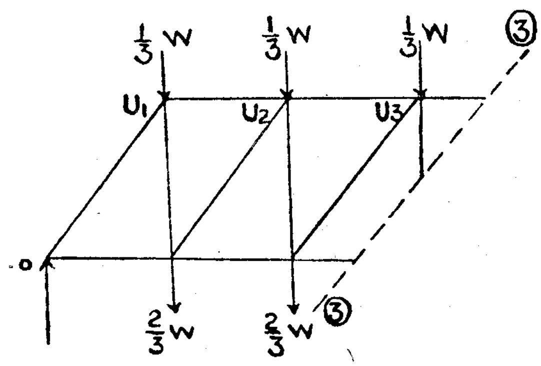
Fig. 94.

(*c*) To find stress in vertical U_3L_3 (Fig. 92)

$\therefore \; S_{U_3L_3} = V_{3\text{-}3} = +\,3 \cdot 09$ in thousands of lb.

Note.—It will be noted that (Fig. 95)

$$V_{3\text{-}3} = \text{shear at section 3–3} = +\,9 \cdot 25 - 2\left(\frac{2}{3} \times \frac{2 \cdot 64}{1}\right) - 3\left(\frac{1}{3} \times \frac{2 \cdot 64}{1}\right)$$
$$= 9 \cdot 25 - 6 \cdot 26$$
$$= 3 \cdot 09 \text{ in thousands of lb.}$$

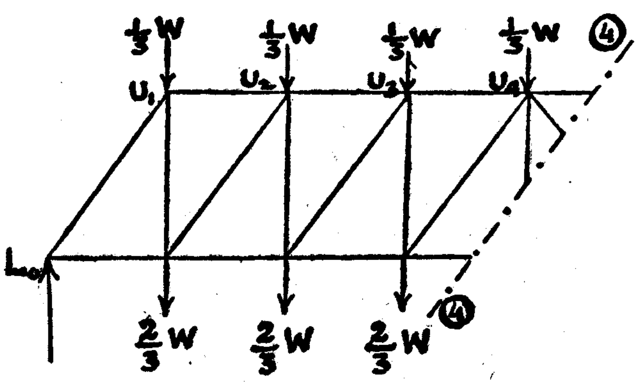


$$V_{3\text{-}3} = +\,9.25 - 2 \times \tfrac{2}{3} \times 2.64 - 3 \times \tfrac{1}{3} \times 2.64$$
$$= +\,9.25 - 6.16$$
$$= +\,3.09 \text{ in thousands of lbs.}$$
$$\therefore S_{U_3L_3} = 3090 \text{ lbs.}$$

Fig. 95.

(*d*) To find stress in vertical U_4L_4 (Fig. 92)

(i) The vertical U_4L_4 cannot be determined by passing a section 4–4, because this section cuts four members, two of which are unknown and hence equation cannot be solved. (Fig. 96).



$V_{4\text{-}4}$ can not be determined by taking section 4-4.

Fig. 96.

(ii) The stress in U_4L_4 can, however, be found by passing a circular section about the point L_4 (Fig. 97) which cuts only three members (including the vertical U_4L_4), out of which, stresses in two members (i.e., L_3L_4 and L_4L_5) are known and hence equation can be solved and the unknown stress in U_4L_4 determined.

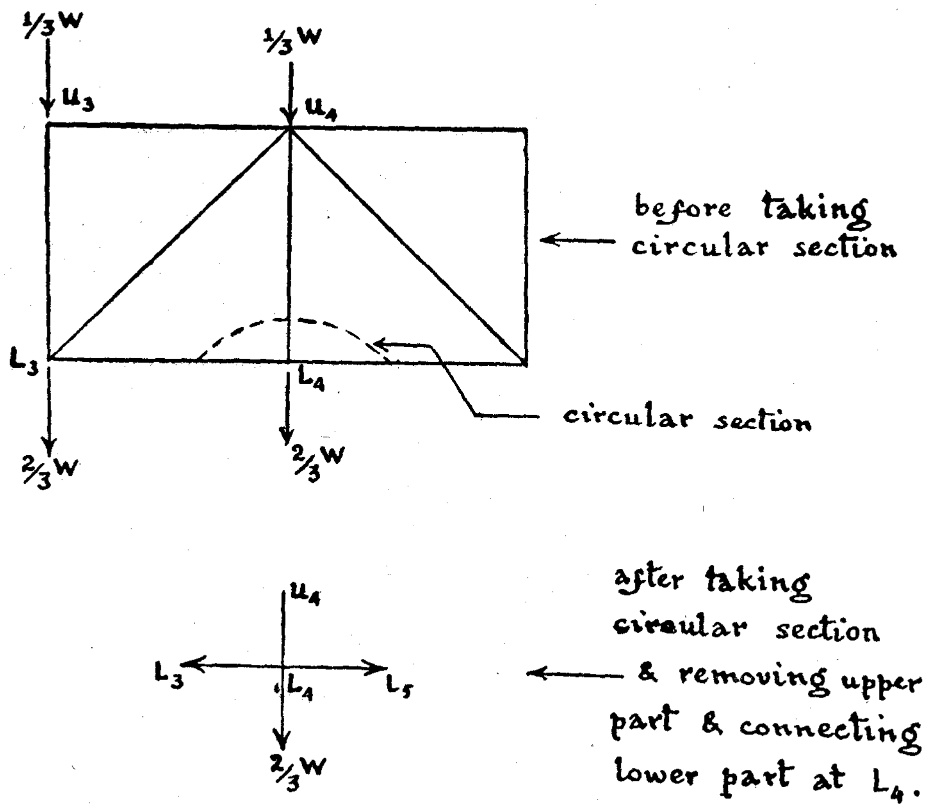


Fig. 97.

(iii) Thus for joint L_4 to be in equilibrium under dead panel loads, it is necessary (Fig. 97)

that $S_{U_4L_4} = \frac{2}{3}$ W because $S_{L_3L_4} = S_{L_4L_5}$

$\therefore \quad S_{U_4L_4} = \frac{2}{3} \times \frac{2 \cdot 64}{1}$ because W at panel points $= 2 \cdot 64$ in thousands of lb.

$\therefore \quad S_{U_4L_4} = + 1 \cdot 76$ in thousands of lb.

Note.—Under panel dead loads, stress in vertical U_4L_4 (i.e., $S_{U_4L_4}$) is equal to panel dead load at point L_4.

(3) Hence stresses in the verticals of the Howe truss due to panel dead loads (only) can be tabulated as follows :—

Members	Stress in lb.	Remarks
$U_1L_1 = U_7L_7$	+8370	(*a*) + sign indicates members in tension.
$U_2L_2 = U_6L_6$	+5730	(*b*) Stresses in vertical members on the right half of truss = the stresses in the corresponding vertical members of the left half of truss (i.e., $S_{U_1L_1} = S_{U_7L_7}$ and so on).
$U_3L_3 = U_5L_5$	+3090	
U_4L_4	+1760	

(H) Stresses in different members of Howe truss due to panel live loads :—

(*a*) Members of top and bottom booms :—

(1) By the same treatment as in paras (D) and (E) pages 133 and 134, stresses in different members of top and bottom booms of Howe truss could be found by considering panel live loads instead of panel dead loads, because we are treating Live load as an equivalent unformly distributed dead load, thereby stressing the bridge members of top and bottom booms in a similar way, only the numerical value changes by the ratio of panel live loads to panel dead load.

(2) Ratio of $\frac{\text{Panel Live load}}{\text{Panel Dead load}} = \frac{5600}{2640}$ [Refer page 130 and 132 para (B) (2) and (B) (5)]

$= 2 \cdot 12$ (approx.).

(3) Hence stresses in members of top and bottom booms of Howe truss can be determined by

Rule (*5*).—Multiplying the chord stress due to panel dead load of a member under consideration, by the ratio of live to dead loads (here this ratio is 2·12) to get chord stress due to panel live loads in the member.

Hence stresses in members of bottom and top booms of Howe truss due to panel live loads can be tabulated as follows :—

Members (Left half of Truss)	Original Panel dead load stress (in thousands of lb.)	Multiplying factor	Deduced stress in members due to Panel live loads (in thousands of lb.)	Members (Right half of Truss)
Bottom Boom :—				
$L_0 L_1$ =	+ 9·25	2·12	+ 19·61	= $L_8 L_7$
$L_1 L_2$ =	+ 15·85	2·12	+ 33·60	= $L_7 L_6$
$L_2 L_3$ =	+ 19·80	2·12	+ 41·97	= $L_6 L_5$
$L_3 L_4$ =	+ 21·10	2·12	+ 44·73 (+ sign indicates that members are in tension)	= $L_5 L_4$ [Refer page 135 para E(2) note 3].
Top Boom :—				
$U_1 U_2$ =	− 9·25	2·12	− 19·61	= $U_7 U_6$
$U_2 U_3$ =	− 15·85	2·12	− 33·60	= $U_6 U_5$
$U_3 U_4$ =	− 19·80	2·12	− 41·97	= $U_5 U_4$ [Refer page 135 para E(2) note 3].

(J) Calculation of panel live load shears :—

(1) Introduction :—The dead load by reason of its nature, is (a) an unchangeable load.

The result is that the stresses in the members of the truss are the same at any and at all times.

(2) With the live load, the case is different. The live load represents the movement of traffic upon the bridge. At certain times

(*a*) there may be no live load on the bridge, while at other times
(*b*) it may fill the bridge partially or
(*c*) fill it entirely.

The results in such cases [as in para 2(*a*), (*b*) and (*c*)] of no live loads, partial live loads or complete live loads, are that the shears due to panel live loads will vary.

Note.—It may be noted that we are treating the total live load as an equivalent uniformly distributed dead load. [Refer page 132 para (B)5 under introduction].

(3) Our problem is, therefore, to find out under which phase or phases of the live loading mentioned in para J(*2*) under (*a*), (*b*) and (*c*), the shears in the panels are maximum to give us the greatest stress for safe design of members.

Procedure :—

(4) It can be shown that

Rule 6(*a*) : maximum positive shear at any section (say x) of a simple beam occurs when the beam is uniformly loaded from that section (i.e., x) to the right support (Fig. 98*a*), and that

Rule 6(*b*) : maximum negative shear occurs at the same section (i.e., x) when this beam is uniformly loaded from the section (i.e., x) to the left support (Fig. 98*b*).

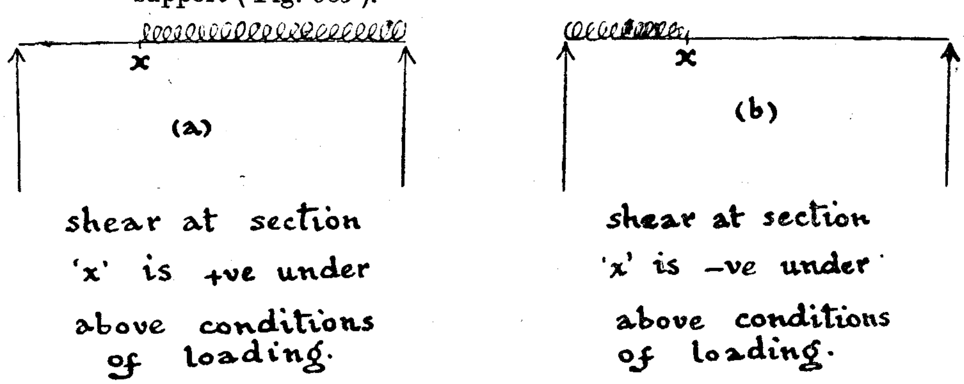


FIG. 98.

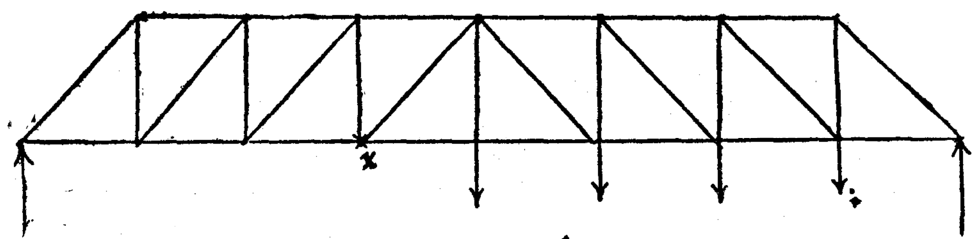
[*Note.*—Refer Appendix VI for proof of above statement].

(5) In a truss, loads are assumed to be placed at panel-points and hence

(*a*) To get max. positive shear at a section 'x' (see Fig. 99*a*) load all panel points to the right of panel 'x'. Now the reaction R_1 produced by the loadings gives value of max. positive shear at panel point 'x'.

(*b*) To get max. negative shear at a section 'x' (Fig. 99*b*) load all panel points to the left of the panel point x. Now reaction R_1 minus the loads ($L_1 + L_2$) produced by the loadings at L_1 and L_2 gives value of max. negative shear at panel point x.

Note.—It should be noted that in the calculation of shears, the height of the truss does not come in.



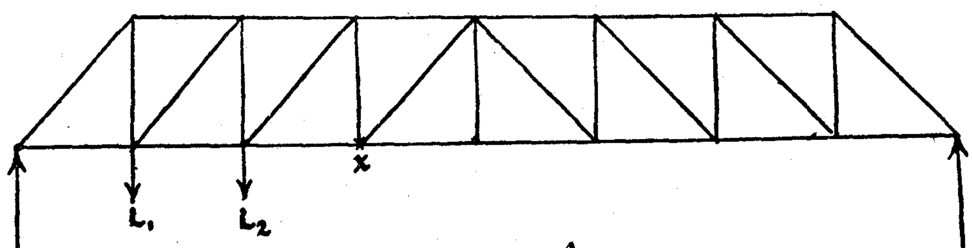


fig. 99.

APPENDIX III

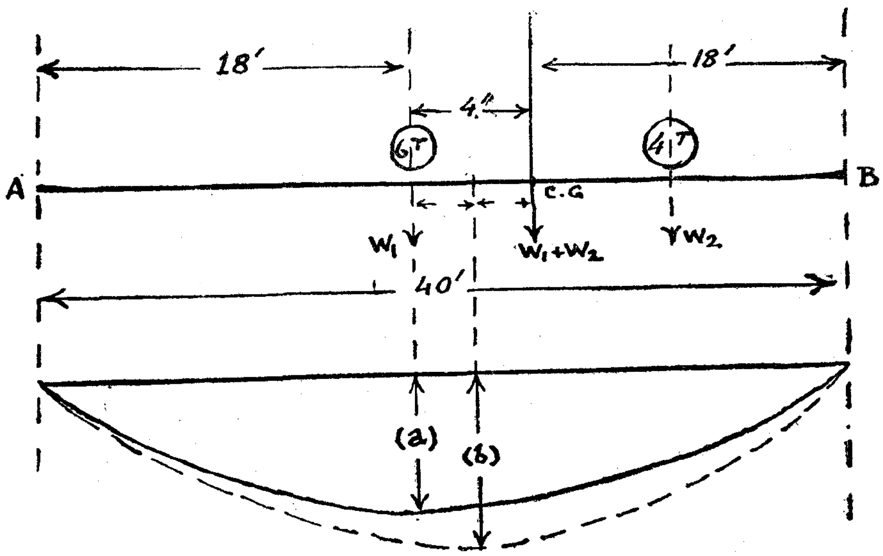
[Reference page 131 para B(4)]

(1) The formulæ

$$w = \frac{2 (W_1 + W_2) (L - x)}{L^2} \text{........(Empirical formulæ)}$$

$$\text{i.e., } wL = \frac{2 (W_1 + W_2) (L - x)}{L}$$

has been found to give a vary practical value for 'w' (the E.D.D.L. due to live load of two axles), because the B.M. diag. (dotted parabolic curve) drawn with this 'w' as E.U.D.D.L., includes and closely approximates the actual B.M. diag. (shown in full line) for a Road Roller (or engines of this type carrying two axle loads). Hence this formulæ is widely used in practice. (See Fig. 2 and also refer Fig. 72 Pt. V*a*).



— line showing actual B.M. curve of two loads traversing the span at a fixed distance apart

- - - B.M. curve (parabolic) drawn from the value of 'w' from the empirical formulae.

(a) = Max. B.M. ordinate for full line curve —.

(b) = Max. B.M. ordinate for dotted line curve - - -.

fig. 2.
(APPENDIX)

(2) From the moving load theory, for max. value of B.M. [as shown at (*a*) ordinate Fig. 2], the wheel under which the max. B.M. occurs (i.e., wheel W_1, i.e., wheel carrying the greater load) and the centre of gravity of the total loads (i.e., $W_1 + W_2$), must be at equal distances from the supports.

This requires the centre (C) of beam AB to be midway between the load (W_1) under which the max. B.M. occurs, and the C.g. of loads. (Fig. 2).

(3) Note that if W_1 and W_2 were to move as a single load of W (i.e., one axle load), then to produce the same max. B.M. at centre due to this W, a E.U.D.D.L. of twice its value (i.e., wL = 2W) would be sufficient and on the safe side of design.

APPENDIX IV

[Reference page 133 para D(1) Rule 1]

Proof of :—

The stress in any chord member (of either top boom or bottom boom)
$=$ sum of shears in the panel up to that section $\times$ Tangent ϕ

See Fig. 3

(1) To find stress in the chord member S_x of top boom.

(2) Pass a section a—a and remove that part of the Fig. 3, which is below section a—a.

(3) Now from Fig. 4

S_1 = Stress in diagonal one $= - V_1 \sec \phi$ where

V_1 = vertical shear at section $1 - 1$

and $-$tive sign indicating that member is in compression.

similarly ϕ = the angle, diagonal makes with the vertical

$S_2 = - V_2 \sec \phi$

$S_3 = - V_3 \sec \phi$ and so on

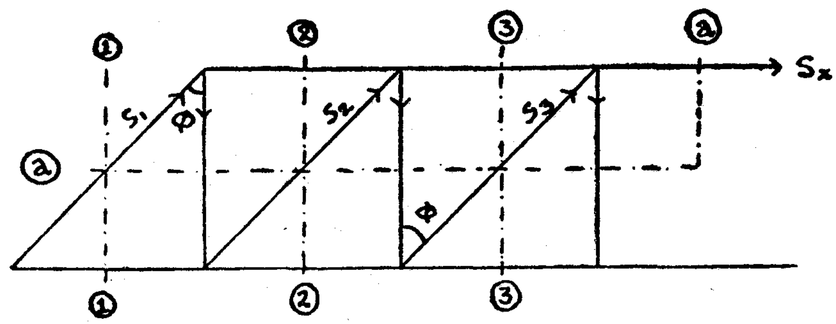


Fig. 3.

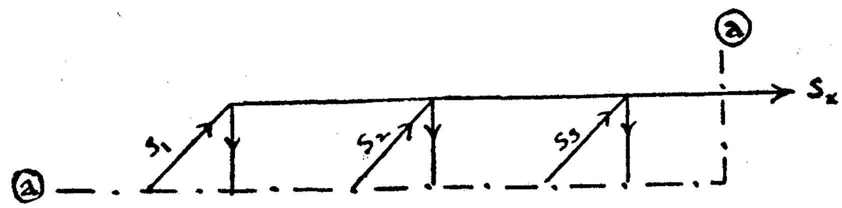


Fig. 4.
(APPENDIX)

(4) Assuming S_x to act away from the section as indicated by the arrow at S_x in Fig. 3 and Fig. 4 and equating the horizontal forces to zero for equilibrium we have

$$S_1 \sin \phi + S_2 \sin \phi + S_3 \sin \phi + S_x = 0 \ldots\ldots (A)$$

Note.—(Assuming $+$tive sign for forces going towards Right
and Assuming $-$tive sign for forces going towards Left)

where $S_1 \sin\phi$ = horizontal component of stress S_1 in diagonal 1
and $S_2 \sin\phi$ = ,, ,, ,, S_2 ,, 2
and $S_3 \sin\phi$ = ,, ,, ,, S_3 ,, 3

(5) Now substituting values of S_1, S_2, S_3 from para (3) above we have eq. (A) as

$$+\ (-V_1 \sec\phi)\sin\phi + (-V_2 \sec\phi)\sin\phi + (-V_3 \sec\phi)\sin\phi + S_x = 0$$

Now $\sec\phi = \frac{1}{\cos\phi}$ and $\sec\phi \sin\phi = \frac{1}{\cos\phi}\frac{\sin\phi}{1} = \tan\phi$

$\therefore$ eq. A finally becomes

$$-V_1 \tan\phi - V_2 \tan\phi - V_3 \tan\phi + S_x = 0$$

$$\therefore\ V_1 \tan\phi + V_2 \tan\phi + V_3 \tan\phi = +S_x$$

i.e. $+S_x = V_1 + V_2 + V_3 \tan\phi$

$= V \tan\phi$

$\therefore$ Numerical value of Stress in any chord member
= sum of shears in the panels up to that section $\times \tan\phi$

APPENDIX V

From 'Bridge Engineering'—by Dufour Schanty

[Reference page 136 para F(4) Rule 3]

Proof of :—

Stress in a diagonal of a truss with horizontal chords
$= V \sec\phi$
where V = Shear of the section considered
ϕ = angle which diagonal makes with the vertical.

Considering Fig. 5 we have

(I) By the resolution of vertical forces we have the eq.

$+R - P - P - S_x \cos\phi = 0$..................................A

Note.—Assuming forces upwords +tive
and assuming forces downwords −tive.

(II) But $R - P - P = V$, the vertical shear at the section $S - S$

$\therefore$ Substituting in eq. A we have

$V - S_x \cos\phi = 0$

i.e., $V + (-S_x \cos\phi) = 0$..................................B

where V = the vertical shear at section $S - S$
and $S_x \cos\phi$ = the vertical component of the stress
S_x (which is a member cut by the section $S - S$).

(III) Therefore, generalizing eq. 'B' we have the rule that 'The algebric sum of the vertical shear at the section and the vertical components of the stresses in all of the members cut by that section, is equal to zero'.

(IV) In trusses with horizontal chords and a simple system of bracing (viz., a Howe truss), the equation B can be written as

$S_x \cos\phi = V$

$\therefore S_x = V \sec\phi$......................................C

(V) Therefore, generalising eq. 'C' we have the rule [refer page 136 para F(4)] that 'Stress in a diagonal (S_x) is given by the product of the shear (V) at the section (S – S) which cuts diagonal and the secant of the angle (ϕ), the diagonal makes with the vertical.

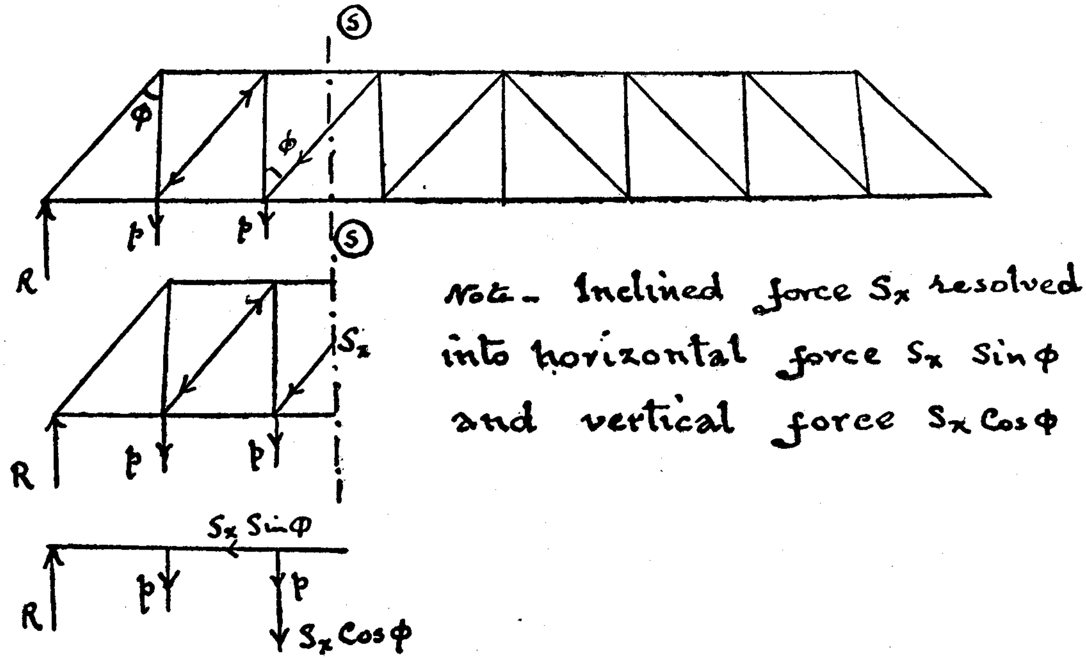


Fig. 5
(APPENDIX)

APPENDIX VI

The statement regarding determination of shear [ref. page 141 para J(5)] can be proved as follows :—

(1) Let a beam Fig. 6 be loaded with 'w' lb. per ft. run. (In our case this is the equivalent uniformly distributed dead load derived from a 7-ton live load given to one truss by a 10-ton road roller moving on the bridge (see Fig. 73, Pt. V*a*).

(2) Referring Fig. 6

Let a — a be the section at which the nature of the shear is to be considered.

(3) The reaction R_1 is given by (taking moments about B)

$$R_1 \times l = wx\left(\frac{x}{2} + y\right) + wy\left(\frac{y}{2}\right)$$

$$\therefore\ R_1 = \frac{wx\left(\frac{x}{2} + y\right) + wy\left(\frac{y}{2}\right)}{l}$$

(4) Now shear at section a — a is

$V_{a-a} = + R_1 \quad - wx$ ....Using same covention, i.e., force up wards + and force downwards —tive

$$= \frac{wx\left(\frac{x}{2} + y\right) + wy\left(\frac{y}{2}\right)}{l} - wx$$

$$V_{a-a} = wx\,\frac{\left(\frac{x}{2} + y\right)}{l} - wx + \frac{wy^2}{2l} \text{ .... eq. (1).}$$

(5) Now $\frac{\frac{x}{2} + y}{l}$ is always < 1 (This is obvious from Fig.)

Hence in eq................$wx\,\frac{\frac{x}{2} + y}{l} - wx$ shall always

be —tive because wx × (something < 1) — wx will give negative result.

(6) Therefore, rewriting eq...................we have

$$\text{Total shear @ a — a} = \frac{wy^2}{2l} - wx\left[1\,\frac{\left(\frac{x}{2} + y\right)}{l}\right] \text{ ....eq. (2).}$$

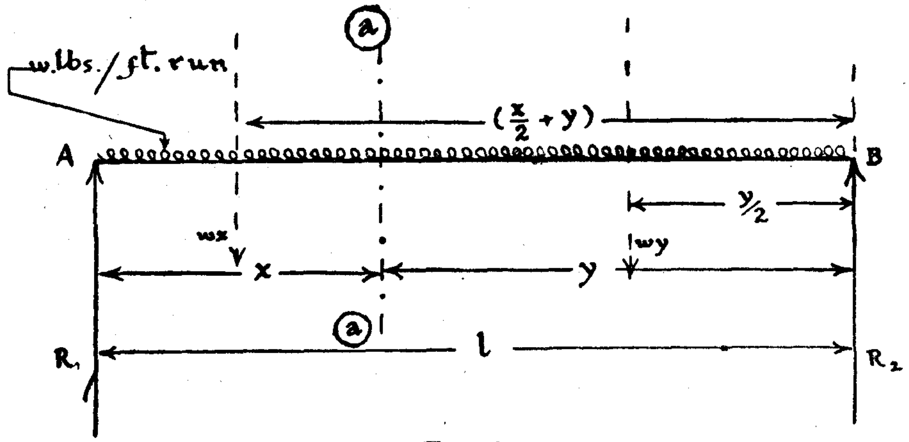


FIG. 6

Result.—

(*a*) The total shear in eq. (2) is maximum positive only when x = 0 and then the max. value of shear at a — a is $+ \frac{wy^2}{2l}$

i.e., max. +tive shear at a section occurs when beam is loaded to the right of section a — a, i.e., in the portion 'x' of the beam, there is no load (refer also Fig. 98*a*).

(*b*) Similarly total shear in eq. (2) is maximum negative only when $y = 0$ and then max. negative shear at a — a is $wx\left[1 - \frac{x}{2l}\right]$ i.e., max. — tive shear at a section occurs when beam is loaded to the left of the section a — a, i.e., in the portion 'y' of the beam, there is no load (refer also Fig. 98*b*).

(continued)

COLLAR ROT OF *DALBERGIA SISSOO* ROXB. DUE TO *RHIZOCTONIA* (*CORTICIUM*) *SOLANI* KUHN

BY K. A. MAHMUD AND K. G. NEMA
(*Agricultural Research Institute, Nagpur*)

In July 1949, seedlings of *Shisam* (*Dalbergia sissoo* Roxb.) in a nursery at Nagpur were affected with collar rot to the extent of 20 per cent. All of the 50 affected plants cultured yielded *Rhizoctonia* (*Corticium*) *solani* Kuhn. The above organism has not so far been reported on *Shisam*.

SYMPTOMS

The disease occurs on one to two weeks old seedlings under moist conditions. It is indicated by a yellowish to brownish discolouration of the hypocotyl at the soil surface. The discoloured area often becomes slightly constricted. The affected seedling gradually dries away. The mycelium of the pathogen is present in all the tissues of the affected collar. It is both inter and intra-cellular.

ISOLATE

The isolate produces a thin stroma-like layer on rice-meal agar, covering the surface of the petridishes (10 cm.) at the room temperature (24–30 C) in 4 days. The colonies gradually turn from dull white to buff. The discolouration of the medium is very inconspicuous. The sclerotia are formed on the 6th or 7th day of incubation both on the medium as well as the glass surface of the petri-dishes. They are chocolate-brown, globose to oblong, often flattened on one side and measure 0·5 to 3 mm. in diameter. Several sclerotia often become agglomerated into irregular masses as large as 1cm.

The mycelium consists of uniformly thick and monilioid hyphae. The main or uniformly thick hyphae are composed of cylindrical cells which measure 48 to 144 μ in length (average 108 μ) and 2·6 to 9·0 μ in width (average 4·8 μ). The branches arise at right or at lesser angles. They are usually constricted at the base. The basal septa in the branches are formed at a distance of 4·5 to 12 μ (average 10 μ). The main hyphae are colourless at first, but with age some of them turn yellowish-brown. The monilioid hyphae are composed of 1 or 2 to 18 barrel-shaped cells which measure 16·5 to 24 μ in length (average 21μ) and 9 to 12 μ in width (average 10·5 μ). They are colourless at first, but with age turn buff to light-brown. Some of the cells in a monilioid hypha may be empty. The cells containing protoplasm readily germinate in water, sending out germ-tubes from the apices or from the septa through the connected empty cells. Some of the monilioid hyphae branch out repeatedly, forming sclerotia. The cells composing the sclerotia are almost round to pyriform and measure 12 μ to 24μ in length (average 16·8 μ) and 9 to 15 μ in width (average 12·6 μ).

PATHOGENICITY

The isolate was tested for pathogenicity on autoclaved soil in pots. 47 per cent of the seedlings in the inoculated pots developed the characteristic symptoms of the disease in 7 to 15 days after germination. The pathogen was invariably reisolated from the affected seedlings. All of the seedlings in the control pots remained healthy.

ACKNOWLEDGEMENT

Our thanks are due to Dr. R. P. Asthana, M.SC., Ph.D. (LONDON), D.I.C., F.A.SC., Mycologist to Government, Madhya Pradesh, for the facilities accorded for work.

G. & T.C.—P.O.—J.S. 43—20-1-51—800 bks.

FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

BY PROFESSOR E. P. STEBBING, M.A.

(*Fellow of the Linnean Society, Fellow of the Royal Geographical Society, Fellow of the Royal Society of Edinburgh. Honorary Member of the Society of American Foresters, formerly of the Indian Forest Service, now Head of the Department of Forestry, University of Edinburgh*).

PART III

(*Continued from the* "Indian Forester", *February 1951, page 108*)

ALBERTA

The Forest Reserves, comprising the Rocky Mountain Reserve chiefly occupy the western part of the province moving from North-West southwards to the South-West. Definite information on the river systems was not forthcoming.

On the subject of the forests the Director of Forestry wrote—

"In regard to the amount of forest still standing on the upper reaches of the mountains and hills of the main rivers, I would advise you that we have no inventory of our forest resources, but you will notice from the map of Alberta that the east slope of the Rocky Mountains is covered by two National Parks controlled by the Dominion Government and by provincial forest reserves controlled by this Department. The forest reserves and parks were set up prior to 1912 and then given very close supervision and protection during that period. Outside of the boundaries of the forest reserves there is still a fringe of forest area which is thin to the south, widens as it goes north, bends roughly along the North Saskatchewan river to where it leaves the province in Township 53".

So far as can be estimated about five-eighths of the province is reserved forest. Of the rest, one-half is fully settled and an equal area not yet fully settled. Of the fully settled area it is estimated that approximately one-third of it is still in bush.

The main rivers flowing through Alberta are—

Bow river, North and South Saskatchewan, Athabaska, Red Deer, and Peace river.

SASKATCHEWAN

The map showing a broad forest and land classification of Saskatchewan has the following legend of areas :—

Pre-Cambrian Shield 94,343 square miles ; mixed wood forest of four types—Provincial forests (protected) 13,300 square miles ; additional protected forests 6,214 ; potential commercial forest 22,795 square miles ; settled land in mixed wood forest 12,910 square miles ; and lastly, main settlement lands 102,138 square miles.

Mr. E. J. Marshall, Director of Forests, has drawn up what may be termed a model reply to the questionnaire which was sent to him—I give it here in his own words :—

"The main rivers of Saskatchewan in order of importance are as follows :—

1. SOUTH SASKATCHEWAN

Length in Saskatchewan.—700 miles to its confluence with the North Saskatchewan river east of Prince Albert.

Source.—Mountains of south-western Alberta. It is fed mainly from mountain glaciers with a small addition to the flow from prairie country.

2. NORTH SASKATCHEWAN

Length in Saskatchewan.—Approximately 400 miles. Overall length from source to Lake Winnipeg 1,400 miles.

Source.—Rises in the Rocky Mountains, fed by glaciers 351 miles west of Edmonton. Traverses the central prairies and southern portion of the wooded country between the fairly well timbered park-like country east of the Rockies and Hudson Bay via Lake Winnipeg.

3. CHURCHILL RIVER

Length in Saskatchewan.—Approximately 400 miles. Overall length 1,200 miles from source in Methy Lake, Saskatchewan to Hudson Bay.

Source.—Methy Lake and also Beaver river through a long series of irregular lakes. It flows through the Pre-Cambrian with its northern bank roughly defining the boundary of the thickly forested area.

4. BEAVER RIVER

(tributary to the Churchill)
(or source of the Churchill)

Source is west of Cold Lake, Alberta.

Length to the Churchill river 200 miles.

5. CARROT RIVER

(tributary to the Saskatchewan)

Length in Saskatchewan.—To the North Saskatchewan river at the Pas—200 miles.

Source.—Wooded country west of the town of Tisdale.

6. QU'APPELLE RIVER

Length in Saskatchewan.—300 miles to confluence with the Assiniboine east of the East Saskatchewan boundary.

Source.—A small lake south-east of the town of Elbow and close to the South Saskatchewan river. It is the largest tributary of the Assiniboine river of Manitoba.

7. MONTREAL RIVER SYSTEM

(tributary to the Churchill river)

Length of river and lake chain from Waskesiu to Churchill river.—175 miles.

Source.—Waskesiu Lake in Prince Albert National Park.

The Mudjatik river, Smoothstone, Haultain, Foster and Reindeer rivers are all tributary to the Churchill river".

One of the great so-called Dust Bowls was formed by over cropping the rich prairie grasslands of the south. But it is not only the overcropping of part of the rich lands which has impoverished the province—fire has played a heavy part as Mr. Marshall shows—

"As your enquiry touches on the relation between forest cover in relation to drainage basins I should mention that a large part of the original forest cover of

Saskatchewan has been burned over the years and has been quickly replaced in most cases by a thick poplar growth. This must have had a marked effect on catchment basins and drainage in general. Approximately 24,137 square miles has been burned since the year 1913 out of a total forested area of 63,700 square miles".

Under 'Watersheds' Mr. Marshall gives the following information on the heights of land forming watersheds for the main rivers—

"*Pasquia Hills.*—This height of land forms a small watershed for the Carrot river in the East Central part of the province. This is not an area of great relief and logging has been confined to the gentler sloping places. The tops of the ridges are well forested with normal forest. It is about half logged over but well covered with vegetation that has since grown in.

"*Prince Albert National Park.*—This forms a minor watershed for the major park lakes which are drained through Montreal Lake to the Montreal river and a chain of lakes into the Churchill at Lac La Ronge. The major watershed of which the National Park forms a part has been heavily burned over but has grown back to Aspen, Poplar.

"*High Rock Lake Area.*—This appears to be the approximate centre of a watershed which on the north drains to the Arctic and McKenzie river and to the south into the Churchill river. This area is very sparsely timbered and for the most part a mineralized rock zone which is very barren territory.

"Agricultural area (*Southern Saskatchewan Prairies*).—This constitutes almost half of the total provincial area and serves as a watershed for the South Saskatchewan river".

Generally speaking, the heavily timbered country is bounded on the north by the Churchill river.

Mr. Marshall ends, "I am sorry that there are no written works covering the subject of your letter but as you suggested I have roughly drafted out a picture of our drainage in relation to heights of land and the forested areas. I hope that the enclosed maps will make up for any gaps in the above outline".

Certainly the maps forwarded with his letter help to evaluate the position to a great extent, though the information as to the exact amount of forest standing on the catchment areas is not yet clearly defined.

The rough sketch map showing the main drainage systems of Saskatchewan prepared by R. F. Arnold, Department of Natural Resources, in March 1949, is a valuable asset to have. Also the map roughly showing the areas of the two big burns (fires) in the forest regions—the one in central and south-eastern area where 50% was cut over and the rest burnt ; and the other area in west and west-north-west forest region where a severe burn was experienced.

BRITISH COLUMBIA

In all directions of forest work British Columbia progressed in 1947 as is shown in the "Report of the Forest Service" for that year. An important departure was the passing of an amendment to the Forest Act—

"Providing for the creation of forest management licence areas, with the object of facilitating the practice of sustained-yield management of the forest resources by the forest industries".

"This outstanding piece of legislation ranks with the formation of the Forest Service thirty-five years previously in importance as a progressive step in the development and perpetuation of our forest resource".

Important increases, says the report, will be noted in practically all the statistical tables accompanying this report. As a single indicator, the timber-cut increased 1,000,000,000 feet, an all-time record and an increase of more than 30 per cent over the cut in 1946.

Total value of production increased accordingly. Lumber alone showed an increase in value of over $68,000,000 (from $87,013,502 to $155,761,222) and pulp and paper values moved upwards from $41,800,555 in 1946 to $57,145,678 in 1947. Shingle values showed an increase of over 100 per cent, as did plywood. The total value of all products was $282,288,388 as compared with $173,471,370 in 1946: The average stumpage price bid on timber-sales was $2·80 per M. an increase of 41 cents per M. or 17 per cent over 1946.

Douglas Fir again led the species cut with 1,652,193,732 F.B.M., hemlock ranked second with 823,063,771 F.B.M., cedar third at 814,193,127 F.B.M., and spruce fourth with 385,662,832 F.B.M. The aggregate cut was 4,187,816,199 F.B.M., comprising all products. A total of 2,469 timber-sales was made during the year, 158 less than the record set in the previous year.

There was a total of 1,634 operating saw-mills, 406 more than in 1946 and 73 shingle-mills, an increase of 14.

It is not actually apparent from the report whether any regulation on the annual volume of timber cut is in force. Obviously until the whole forest area has been checked and its volume of mature timber per square mile is known the annual fellings have no area or volume check on over-cutting. How long can those soaring felling figures be permitted without killing the bird laying these golden eggs ?

And where are these unchecked fellings taking place ? In how far are the catchment areas being protected ?

Mr. David K. Monk (for Mr. Eric Druce, Forester) in a letter giving details of the British Columbian forests on the chief rivers and their tributaries writes under the heading—

"Details on the chief rivers of British Columbia are as follows :—

FRASER .. 785 miles long : rises in the Rocky Mountains near Yellowhead Pass ; empties into Georgia Strait at Vancouver, B.C.
Principal Tributaries.—Mirkill, Bowron, McGregor, Willow, Salmon, Mechake, Blackwater, Cottonwood, Quesnel, Chilcotin, Bridge, Thompson, Harrison and Pitt rivers.
Area of Productive Forest Land at headwaters of Fraser—80,700 acres.
Merchantable Timber in area of headwaters—approximately 675,000,000 f.b.m.

COLUMBIA .. Length in B.C.—459 miles ; rises in Columbia Lake : empties through the State of Washington into the Pacific Ocean.
Principal Tributaries.—(in B.C.)—Canoe and Eagle rivers.
Area of Productive Forest Land at headwaters—approximately 518,000,000 f.b.m.

KOOTENAY .. Total length.—406 miles (276 in B.C. and 130 in U.S.A.) : rises in Rocky Mountains SE. of Golden, B.C. ; empties into Columbia at Castlegar, B.C.

Principal Tributaries.—Elk and Moyie rivers.
Area of Productive Forest Land at headwaters at Kootenay—133,800 acres.
Merchantable Timber.—In area of headwaters—approximately 694,000,000 f.b.m.

SKEENA .. Total length 325 miles: rises north of latitude 57°; empties into Chatham Sound 16 miles south of Prince Rupert.
Principal Tributaries.—Babine and Bulkley rivers.
Area of Productive Forest Land.—At headwaters of Skeena—not accessible.
Merchantable Timber.—In area of headwaters—unknown—not accessible.

PEACE .. Length in B.C. 175 miles.
Starts at Finlay Forks, B.C. and flows east into Alberta.
Principal Tributaries.—Finlay and Parsnip rivers.
Area of Productive Forest Land.—Unknown—not accessible.
Merchantable Timber.—Unknown—not accessible.

In view of the enquiry herewith undertaken and which appears to answer some of my queries above, Mr. Monk ends his remarks with the following :—

> "Within the confines of a letter it is not possible to cover the amount of timber in these areas which may have been destroyed by fire, disease, insects, etcetera. These areas are so vast that any figures are at best only approximations. However, you might find it of interest that over the last decade, B.C. has suffered an average of 1,700 forest fires per year which destroy, annually, approximately 300,000,000 board feet of timber".

NEWFOUNDLAND

Dr. W. A. Fairbairn has kindly prepared the following note on Newfoundland.

Newfoundland is approximately 42,734 square miles in area. The coast is ragged and rocky with deep water running up to the cliffs which rise to a considerable height. There is a series of bays into which a large number of the rivers disgorge. The rivers are usually of no great length, except for the Gander, the Humber and the Exploits rivers. There are innumerable lakes covering approximately one-third of the Island; some are of considerable length and many fill in the deep valleys between mountains. The highest mountains are in the north-west and rise from sea-level to 2,200 feet. The vegetation of the coast is tundra-like.

Area Statement:

Total area of forest	17,144 sq. miles.
Total land area (excluding water surfaces)	17,013 ,, ,,
Forest area as a percentage of total land area	40·6%
Exploitable State coniferous forest	4,030 sq. miles.
Exploitable Private forest	10,361 ,, ,,

The forests of Newfoundland are natural, uneven-aged and systematic thinning has never been undertaken.

The commercial species are Black Spruce (*P. mariana*) White Spruce (*P. canadensis*) Balsam Fir (*Abies balsamae*), White Birch (*Betula papyrifora*) and Yellow Birch (*Betula lutea*).

Spruce and fir are, of course, largely used in the manufacture of pulp and paper and for sawn lumber.

Between 1895 and 1905 large fires took place in the interior of the Island, destroying large areas of natural forest. Natural regeneration was good over most of the areas and they now carry fairly heavy stands of spruce and Balsam up to 50 years old. The paper companies draw a considerable part of their pulpwood supplies from these regenerated stands.

MAIN RIVERS AND TRIBUTARIES

East Coast

Salmon River	.. River and tributaries approximately 90 miles in length flowing into Hare Bay.
Beaver River	.. Approx. 60 miles, flowing into Chimney Bay.
Soufflets River	.. Approx. 40 miles, flowing into Orange Bay.
Catarm River	.. Approx. 80 miles, flowing into White Bay.
Main River	.. Approx. 180 miles, flowing into White Bay.
Indian Brook	.. Approx. 175 miles, flowing into Notre Dam Bay.
Exploits River	.. Approx. 1,000 miles, flowing into Notre Dam Bay.
Gander River	.. Approx. 600 miles, flowing into Gander Bay.
Terra Nova River	.. Approx. 200 miles, flowing into Bonavista Bay.
La Manche River	.. Approx. 70 miles, flowing into Atlantic.

South Coast

Biscay Bay River	.. Approx. 50 miles, flowing into Trepassey Bay.
Salmonier River	.. Approx. 80 miles, flowing into St. Mary's Bay.
Rocky River	.. Approx. 40 miles, flowing into St. Mary's Bay.
Black River	.. Approx. 20 miles, flowing into Placentia Bay.
Pipers Hole River	.. Approx. 60 miles, flowing into Placentia Bay.
Sandy River	.. Approx. 50 miles, flowing into Placentia Bay.
Paradise River	.. Approx. 25 miles, flowing into Placentia Bay.
Long Harbour River	.. Approx. 90 miles, flowing into Fortune Bay.
North Bay River	.. Approx. 100 miles, flowing into Fortune Bay.
Lonne River	.. Approx. 120 miles, flowing into Hermitage Bay.
Hare River	.. Approx. 90 miles, flowing into Hare Bay.
Little River	.. Approx. 150 miles, flowing into Atlantic.
White Bear River	.. Approx. 100 miles, flowing into Atlantic.
Grandy Brook	.. Approx. 60 miles, flowing into Atlantic.
Grandy's Brook	.. Approx. 50 miles, flowing into Atlantic.

West Coast

Crabb's River	.. Approx. 90 miles, flowing into Gulf of St. Lawrence.
Fishels Brook	.. Approx. 70 miles, flowing into Gulf of St. Lawrence.
Harrys River	.. Approx. 100 miles, flowing into Gulf of St. Lawrence.
Humber River	.. Approx. 550 miles, flowing into Gulf of St. Lawrence.
East River	.. Approx. 20 miles, flowing into Gulf of St. Lawrence.

North Coast

Nil.

SOUTH AMERICA

It is due to William Vogt and his office that I owe such information as I have been able to glean on the South American forests and some of the catchment areas. The information on the rivers is mostly obtained from the American Geographical Society.

On the subject of the forests Vogt writes :

"I am sorry not to be able to send you information on South American forests, but this simply does not exist".

Dealing with the rivers, Vogt added "During my absence my staff has compiled the best available information on South American rivers. This is sent to you. My own evaluation" Vogt adds, "is that the material from the American Geographical Society is the most reliable".

It is given below.

"We have done extensive research on this subject and you will find our results below. As far as we know, there is no other available compilation. Several sources have been consulted, and you will, therefore, find the lengths of the rivers given in both miles and kilometres. In many cases, only the longest rivers in each area were mentioned, but it must be kept in mind that frequently small streams in arid areas overshadow in importance great rivers in humid areas".

The latter remark anent the "small streams" has a very important bearing on the question herein under consideration in some parts of the world.

Rivers and tributaries	*Length*	*Rivers and tributaries*	*Length*
Amazon	4,000 mi.	La Plata-Parana	2,450 mi.
Tocantins	1,700 mi.	Uruguay	1,600 km.
Xingu	1,200 mi.	Paraguay	2,078 km.
Madeire	3,000 mi.	Pilcomayo	1,200 km.
Purus	1,800 mi.	Iguassu	1,320 km.
Ucayali	1,960 km.	Orinoco	1,700 mi.
Putumayo	1,580 km.	Apure	900 km.
Yapura	1,848 km.	Arauca	740 km.
Negro	1,551 km.	Casiquiare	205 km.
Tapajos	1,990 km.	Meta	1,100 km.
Branco	640 km.	Sao Francisco	1,811 mi.

Other important rivers listed for the various countries are as follows :—

Country	*River*	*Length*
Argentine	Salado	1,300 km.
,,	Bermejo	1,200 km.
,,	Colorado	1,000 km.
,,	Rio Negro	750 km.
,,	Neuquen	500 km.
,,	Limai	400 km.
Bolivia	Beni	1,500 km.
,,	Desaguadero	297 km.
Brazil	Araguaya	2,627 km.
,,	Jurua	2,000 km.

Country	*River*	*Length*
Brazil	Guapore ..	.. 1,716 km.
,,	Parahyba ..	.. 1,716 km.
,,	Itapekuru ..	.. 1,650 km.
,,	Ica ..	.. 1,452 km.
,,	Grande ..	.. 1,353 km.
,,	Vilhas ..	.. 1,135 km.
,,	Tiete ..	.. 1,112 km.
,,	Mearini ..	.. 1,100 km.
,,	Jiquitinhonha	.. 1,082 km.
,,	Jutahy ..	.. 1,056 km.
,,	Tiffe ..	.. 990 km.
,,	Doce ..	.. 977 km.
,,	Yavary ..	.. 945 km.
Chile	Loa ..	.. 440 km.
,,	Baker ..	.. 440 km.
,,	Bio-Bio ..	.. 380 km.
,,	Copeapo ..	.. 300 km.
,,	Palina ..	.. 300 km.
,,	Pascua ..	.. 285 km.
,,	Maule ..	.. 280 km.
Columbia	Magdalena ..	.. 1,350 km.
,,	Vichada ..	.. 1,100 km.
,,	Cauca ..	.. 1,090 km.
,,	Atrato ..	.. 665 km.
,,	Sinu ..	.. 460 km.
,,	Patui ..	.. 400 km.
,,	San Juan ..	.. 300 km.
Equador	Rio Napo ..	.. 700 km.
,,	Tigre ..	.. 600 km.
,,	Pastaza ..	.. 520 km.
Peru	Apurimac ..	.. 1,000 km.
Uruguay	Negro ..	.. 750 km.
Venezuela	Cuyuni ..	.. 750 km.
,,	Paragua ..	.. 700 km.
,,	Caroni ..	.. 600 km.

We know little about the watersheds or catchment areas of these rivers or their forested condition. But the following is an extract from Vogt's paper—A Memorandum on the position of the Forests of South America by William Vogt (Conservation Section, Pan American Union, to Mr. Tom Gill, Chairman of the August 1947 Sub-Committee Forestry of the FAO held in Geneva—

"In few parts of the world is the forestry problem as generally misunderstood as in the twenty Latin American Republics, especially those lying within the tropics. There has gained currency a belief that this region holds enormous forest resources that have only to be exploited for the benefits and profit of man. Actually, according to my observations in Chile, Peru, Ecuador, Colombia, Venezuela, Costa Rica, El Salvador, Guatemala and Mexico extending over a period of nine years, there are far less timber resources than is generally believed, even by some professional foresters.

"One of the reasons that I take a more limited view of these resources than do many people, is the physical geography of Latin America, and the pattern of human settlement. The lowlands of Latin America, as of other parts of the tropics, are generally not very desirable for human occupancy because of the high incidence of such diseases as dysenteries, malaria, schistosomiasis, etc. Furthermore, a high proportion of the lowlands is unsuitable for agriculture because of excessively concentrated rains that leach minerals from the soil, long blistering dry seasons that thoroughly desiccate vegetation, once the forest has been cleared, and because high temperatures tend to oxidize very rapidly organic materials in the soils. It is not at all unusual for a tract of land to pass from virgin forest to abandoned brush, when the lowlands are cultivated, within a period of eight or ten years. And because of more drastic ecological changes, regeneration of the forest appears to take far longer than in temperate zones.

"Owing to the resistance of the tropical lowlands to human settlement populations have tended to concentrate above 7,000 metres. In Venezuela, for example, 13% of the country's area consists of mountains ranging up to 4,000 metres. Into this 13% of the area is crowded 70% of the Venezuelan population.

"The best agricultural land in the higher altitudes lies in the intermont valleys but, in part because there is an insufficiency of level land and in part because of concentration of the best lands in the hands of wealthy and influential people, the mass of farmers have been crowded up slopes. Here shifting, or *Milpa*, agriculture is the rule, and a very high percentage of slopes throughout Latin America has been devegetated. This, of course, completely upsets the hydrologic equilibrium achieved by Nature over centuries of slow evolution and, given the Latin American rainfall pattern—three meters a year in southern Chile, three meters per *month* in Costa Rica—sets in motion violent forces. Run-off is rapidly increased, flash floods interspersed with periods of little or no water in the rivers, are the rule : rivers on the western coast of Costa Rica vary as much as 100 to 1 in their flow. Floods scour out alluvial soils and thus reduce available agricultural lands in the intermont valleys. They dump silt, which often consists of sterile subsoil, upon the lowland alluvial soils, and reduce or destroy their productive capacity. Floods submerge potentially valuable agricultural or grazing land downstream and, as in large areas of the Venezuelan llanos, make them useless for months every year.

"This land settlement pattern in Latin America has resulted in the extremely grave situation that there exist probably from *20 to 40 million displaced persons*. They are displaced in the ecological sense, that their present relationship to the land is destroying it at an accelerating rate, not only in the highland areas where they live, but, in the lower areas affected by river flows. Many millions of acres of soil have been seriously eroded in Latin America and, as Professor Stebbing has described in the case of the Sahara, deserts are on the march. One of the worst instances of this land pathology is in El Salvador, where 2,000,000 people, increasing at the rate of 40,000 a year, have available for agriculture only about an acre per capita, and much of this land is of low productivity.

"The extensive lowland forests of Latin America consist of mixed stands that are costly to exploit. In spite of this, valuable trees, such as chicle and mahogany, have been killed or removed over large areas. It is the rule, rather than the exception, to exploit forests along river banks and resulting siltation has contributed to the abandonment of many small ports : the Grace Line, the principal American steamship company running into Barranquilla Colombia, has recently cancelled its service to that

port because of harbour siltation. Not a country in tropical America is provided with an adequate forest fire service, and large areas are burned, in part to prepare the land for shifting agriculture and in part out of sheer wantonness, every year. Well-informed people in Venezuela—an area about twice the size of France—have informed me that at least one-half of their choice timber has already been destroyed. During the last dry season, fires burned enormous areas in Venezuela and damages were alleged to reach several hundred million bolivars.

"Some of the best timber in Latin America is found on the mountainsides. Especially notable are the pines and oaks of Central America and Mexico. These, however, because they are part of a highly unstable landscape, must be cut, if at all, under highly selective methods. In Venezuela I have seen places where clearing of a single small cornfield resulted in a major landslide into the river below. Tree cutting on slopes, from Mexico to Aysen, in southern Chile, has set in motion some of the most violent and widespread soil erosion to be found anywhere in the world. This soil erosion, of course, becomes part of the usual cycle of run-off, siltation, floods, falling water tables, etc.

"Because human populations are concentrated in the highlands roads fan out from upland towns and make especially accessible the upland forests. These are cut not only for timber but for charcoal. Out of the 150 million people living in Latin America, at least 80 million must depend on charcoal for cooking, heating, and many industrial purposes. Until recently, and perhaps down to the present, iron is smelted with charcoal in Chile and Brazil. Brazilian railroads are carting wood seventy to ninety miles, to furnish fuel for their locomotives.

"Not only is almost the entire area of Latin America without adequate fire control: not more than one or two countries possess the technological resources to manage their forests on a sustained-yield basis. As a result, over the major part of the region, except perhaps for the more remote sections of the Amazon valley, one may everywhere see an appalling forest degeneration. On level land, in the lower altitudes, where soil washing may not be such a critical factor, fire and microclimatic changes resulting from forest destruction cause an ecological degeneration such as has been reported from many parts of Africa. This reaches a striking culmination in eastern and south-eastern El Salvador, where an area that was once apparently covered with rich tropical forest has now been taken over by sparse grass of low nutritive value, and mesquite. The two States of Lara and Falcon in Venezuela, with a rainfall of approximately that of the British Isles, have apparently degenerated into the deserts that now occupy them, through similar ecological processes.

"A comparable situation, except for the absence of the impact of tropical environment, exists in southern Chile and in central and northern Mexico. In Chile excessive rains rip the soil from deforested hills, and I have seen many places that were virgin forest twenty years ago, now in abandoned second growth. Correlative with this destruction is the lack of water in nearby towns, the abandonment of the city of Osorno as a port, and the threat to the major port of Corral. The development of the important new center of Aysen, in southern Chile, largely on the flood-plain of the Simpson river, is threatened with disaster for the same cause.

"Many highland Mexican forests were set aside as national parks, as safeguards for major watersheds. Some of these subsequently lost their protection by congressional action, and in other cases the laws were freely violated. Forest fires are common and almost uncontrolled in Mexican forests, national parks are lumbered in spite of restrictions imposed by national laws and international treaties, and overgrazing is evident

in every national park I have seen. There is little mature timber left in the Mexican uplands, and 50–60-year-old second growth often occurs in grassy parks where there is neither understorey nor reproduction.

"The end result of such abuse of forests can be seen in parts of Guatemala where the peasants cannot even make their favourite *tortillas,* or corn cakes, because of lack of fuel : they must be satisfied with *tamalitos blancos,* which are a sort of dried corn-meal mush. Mexican towns have formerly had to go without water for ten or twelve hours a day during the dry season, a situation that is repeated in many countries, even into southern Chile. Recent reports indicate that even in the rainy season the Mexican capital is without water from six in the evening until six the next morning. Along with the lack of water goes a lack of hydro-electric power, frequently resulting from the filling of storage reservoirs with silt, or major landslides".

BRITISH HONDURAS

British Honduras is separated from Mexico on its northern and north-western borders by the River Hondo. As will be seen the worst area of soil degradation due to erosion is in the Toledo district south of the Columbia branch of the Rio Grande. On the southern boundary the River Sarstoon separates the Colony from Guatamala.

Mr. A. L. Lamb, Conservator of Forests for the Colony, has been able to furnish some interesting and valuable information on the subject of the Water Supplies and Catchment Areas of British Honduras. It is a pity we have not a greater bulk of information as complete from other parts of the world.

"Ninety-three per cent of British Honduras is still under forest of one kind or another including pine savannah forests and the upper reaches of all the main rivers of the Colony and their tributaries are 100 per cent forested".

In the enquiry being held in this paper this state of affairs is almost unprecedented. It is to be hoped that the future administration of the Colony will see that the exploitation of these almost untouched forests on the catchment areas is carried out under trained forest officers so as to avoid the appalling and ignorant overfelling which has taken place up-to-date in so many parts of the world.

Mr. Lamb continues—"The chief rivers are :—

1. (*a*) Belize or Old River 350 miles
   (*b*) Rio Hondo (Northern boundary with Mexico)
   (*c*) New River 136 miles low watershed
   (*d*) Freshwater Creek 36 miles low watershed
   (*e*) Northern River 40 miles low watershed
   (*f*) Sibun River 116 miles
   (*g*) Manatee River 36 miles
   (*h*) Mullins River 32 miles
   (*i*) North Stann Creek 84 miles
   (*j*) Sittee River 60 miles
   (*k*) South Stann Creek 60 miles
   (*l*) Monkey River 160 miles two main branches
   (*m*) Deep River 44 miles
   (*n*) Golden Stream 32 miles

(*o*) Rio Grande 94 miles
(*p*) Moho River 84 miles in Colony
(*q*) Temash 36 miles in Colony
(*r*) Sarstoon 44 miles in Colony (southern boundary with Guatamala).

2. (*a*) (i) Macal Branch 44 miles
(ii) Labouring Creek 72 miles
(iii) Black Creek 56 miles series of lagoons
(*b*) (i) Rio Bravo 88 miles
(*f*) (i) Caves Branch 40 miles
(ii) Dry Creek 24 miles
(iii) Indian Creek 28 miles
(*l*) (i) Swasey Branch 88 miles
Bladen is main river
(ii) Trio Branch 32 miles
(*o*) (i) Columbia Branch 24 miles.

3. As almost all is forest it is easier to define the farm lands.
(*a*) Farms and pastures border the river from the Guatamalan frontier down to Belize but do not extend far from the banks as the river was the main artery till the road was built in 1947 to Cayo.
(*b*) 50% of the land is swamp forest between Rio Hondo and New river, remaining 50% is partly shifting cultivation and partly sugar-cane and fruit orchards. Soil is limestone, area is flat. Upper reaches of Rio Hondo 100% forest.
(*c* to *d*) 80% forest of which 50% is swamp forest 20% farmland sugar and corn, latter shifting cultivation.
(*e*) About 90% forest.
(*f*) 100% forest in upper reaches strip of farmland along lower reaches across coastal plain.
(*i*) Bottom valley citrus orchards and farmlands, hills forest 100%.
(*j*) 100% forest in upper reaches farms from Kendal down along banks.
(*m*) 100% forest to mouth.
(*n*) 100% forest to mouth.
(*o*) 90% forest 10% shifting cultivation.
(*p*) 95% forest 5% ,, ,,
(*q*) 95% forest 5% ,, ,,
(*r*) 99% forest 1% ,, ,,

4. (*a*) (i) and (ii) 100% forest.
(iii) 90% ,,
(*b*) (i) 100% ,,
(*f*) (i), (ii) and (iii) 100% ,,
(*l*) (i) and (ii) 80% ,,
(*o*) (i) 50% forest, north side all forest.

5. "The population of the Colony is 60,000 and the area 8,867 sq. miles. Most of the men are forest workers though they may do a little farming on the river banks. Grazing is almost entirely confined to the lower reaches of the rivers and the pine grass plains along the coast. There is no accelerated erosion due to cattle, sheep or goats and very little due to shifting cultivation because most of the cultivated land is flat or is limestone.

"The granite soils of the Mountain Pine Ridge south of Cayo erodes rapidly if the grass cover is removed but it is a Forest Reserve and we have complete control of its use.

"The worst area for soil degradation due to erosion is in Toledo district south of the Columbia branch of Rio Grande. This fertile sedimentary soil is steeply undulating and is farmed by the Mayan Indians on a shifting cultivation system for one year in about eight. They do not hoe up the soil and, therefore, erosion is not as severe as it might be. To all intents and purposes the hills of this country are not farmed at all and as they are nearly all in Crown ownership the use to which they are put is under the Government's control".

BRITISH GUIANA

British Guiana is on a somewhat similar favourable position as British Honduras so far as its catchment areas are concerned. Mr. C. Swabey, Conservator of Forests, who has had considerable experience in Trinidad and other tropical colonies, gives the length of the chief river, the Essequibo, as 650 miles and the names and length of the 4 principal tributaries as Mazaruni 350 miles, Cuyuni 300 miles, Rupununi 270 miles and Kwitaro 200 miles.

"The catchment area of this river system is approximately 50,000 sq. miles: the bulk of it is covered by virgin forest, much of it is uninhabited and virtually unexplored. Savanna areas total approximately 8,000 sq. miles and are not over-grazed. The total population of this area is probably less than 10,000 : a few Amerindian tribes indulge in shifting cultivation but their effect is negligible (a fraction of 1%)".
Other rivers mentioned are :

DEMERARA RIVER .. Length 245 miles. Settlement and cultivation confined to the lower 100 miles: the higher reaches are forest covered and uninhabited.

CORENTYNO RIVER .. Length 475 miles. The entire upper reaches of this river are in virgin forest country and completely uninhabited. The same applies to its major tributary the New river (220 m.).

BARIMA RIVER .. Length 260 miles (tributaries include Barama R. 180 m.). These rivers are sparsely inhabited by Amerindians engaged in wood-cutting: a little forest is cleared annually for field crops, but the effect is quite negligible".

"Finally, to sum up", Mr. Swabey says, "there is at present no abuse whatsoever of protection forests in British Guiana : the effect of man on the hydrologic balance is absolutely nil".

A most interesting report !

Mr. Swabey's Report was issued in 1949.

In the British Press during February 1950 an article appeared on the subject of British Guiana Timbers, their possible extraction, one of the chief being the well-known Greenhart.

The question of development of the forests according to the writer of the article appeared to be under the Colonial Development Corporation. No allusion is made to the existence of a Forest Department in the Colony and yet as Mr. Swabey's letter indicates the Department is as up-to-date in the forest possibilities as any Development Corporation could be. Two big concessions are being given out, the first of 100 square miles and the second of 500 square miles.

Many Colonies have seen the deplorable results of giving out uncontrolled concessions of forest areas. We should certainly have learnt our lesson in the British Empire. Apparently Messrs. Steel Brothers are to be advisers in the matter to the Corporation. Messrs. Steel Brothers for many years worked in the Burma Teak Forests under the 15 year licence systems which were in force in the Government Forests for eighty years. (See p. 123).

It may be hoped, therefore, that the grant of more or less free licences to timber exploiters in Colonial Forests from which the local population, the real owners of the forests, get little or nothing of the profits, has come to an end.

TRINIDAD

Mr. G. N. Sale, formerly Conservator of Forests, Trinidad, has kindly given me the following information. As in many other parts of our Empire the Forest Department there is struggling against a shortness of staff which makes it difficult to deal with the vital questions involved in the questionnaire.

"Trinidad—1,862 square miles.

Narrow range of mountains up to 3,000 ft. along North coast. Elsewhere a clay or sandy plain interspersed with low clay or calcarcous hills. Rivers frequently slow: erosion delayed by low angle of slope but accelerated by fires in dry season and soft movable nature of soil and subsoil.

Main rivers :—

Caroni, small part of catchment under forest, remainder cultivation, much sugar-cane right to crumbling edge of bank.
Disastrous floods frequent.

Ortoire, catchment mostly under forest.

Poole, catchment mainly cultivated or abandoned cultivation, specially liable to flooding.

Maraval, small river, steep slopes of catchment cultivated without conservation measures ; well marked increase in erosion and frequent flooding.

Moruga, catchment mainly dense forest, river still largely tidal, far up its narrow bed".

JAMAICA

The Conservator of Forests, Jamaica, in sending me particulars wrote :—

"As you suggest in your letter the information given on the attached sheet is in its roughest form and I regret that more precise information is not at present available in Jamaica".

The data given show that considerable devastation thas taken place in the mountain ranges.

Information on the Main Rivers of Jamaica

Reply to Questionnaire as requested by Professor Stebbing, Head of Department of Forestry, Edinburgh, Scotland

Main Rivers (1) Name	Length in Miles	Tributaries (2) Name	Length in Miles	Amount of Forests (3, 4 & 5)
Wag Water ..	97			EASTERN MOUNTAIN RANGE 100,000 acres of state and private forests, now considerably denuded.
Dry River ..	32			
Rio Grande ..	67	Back Rio Grande ..	36	
Swift River ..	45			
Buff Bay River ..	47			
Spanish River ..	38			
Yallahs ..	60			
Negro River ..	50			
Morant River ..	45	E. arm of Morant R.	25	
		W. „ „ „ R.	25	
Plantain Garden R.	69			
Hope River ..	46			
Cane River ..	22			
Montego River ..	43			CENTRAL LIMESTONE PLATEAUS AND COCKPIT COUNTRY 100,000 acres of state and private forests, a certain amount of vegetative cover exists.
Martha Brae River	64			
Rio Bueno ..	23			
White River ..	38			
Rio Nuevo ..	53			
Hector's River ..	38			
Cave River ..	45			
Black River ..	144	One Eye River ..	15	20,000 acres of predominantly swampy woodland.
		Middlequarters R. ..	25	
		Y.S. River ..	25	
		Horse Savannah R. ..	20	
		Smith River ..	10	
Milk River ..	63	Jack's River ..	35	
Rio Minho ..	138	Pinder's River ..	50	
		Thomas River ..	45	
Rio Cobre ..	84	Rio Magno ..	45	
		Rio Doro ..	45	
		Rio Pedro ..	55	
Orange River ..	25			WESTERN MOUNTAIN RANGE 100,000 acres of state and private forests, local denudation with patches of woodland.
Great River ..	102			
New Savanna R. ..	35			
Cabaritta River ..	96	Morgan's Cut ..	15	
		Rickett's River ..	10	
Gooden's River ..	36			

WEST INDIES

Mr. G. N. Sale, recently Conservator of Forests in the Islands writes :—

"The West Indies are lamentably short of statistical information and even if I had access to my scattered belongings (Mr. Sale is now home on leave) I could not supply you with what you need. I have to content myself with giving you a small background picture of each of the countries of which I know something".

St. Vincent.—About 150 square miles.

Small island, high mountains up to 4,000 ft. Forest destroyed in north in 1900 by volcanic explosion. Deforestation elsewhere severe by shifting cultivation. Rivers small and short :

Colonarie, Richmond, Cumberland. Colonarie perhaps best known. Upper part of catchment area ruined forest, say one-third lower part cultivated : erosion severe in most parts of island.

Mr. J. A. N. Burra, Assistant Conservator of Forests, British West Indies, has given me the following information :—

St. Vincent.—

Only the mountain tops are still in forest. Soil conservation works with storm drains and strip planting of grasses on the contour has taken on and there's hope. From the Forestry viewpoint the island is very badly off, mainly due to Arrowroot.

Grenada.—133 square miles.

Mr. Sale writes—

Small island, rather less mountainous but slopes steep, erosion increasing and causing concern locally. Rivers short and rapid. Small blocks of good natural forest and dense thickets of palms, but most of the island either cultivated or abandoned cultivation. Tree crops—cocoa and nutmegs are partial protection but inadequate on steep slopes.

Mr. Burra writes—

At a guess I'd say about one-sixth of Grenada is still forest of a sort. The Grand Etang area is well covered, the Mount St. Catherine area in the north rapidly going down hill with flood, drought and the old story of diminishing returns. Luckily Nutmegs, the island's staple crop provide some protection but due to clean weeding and sweeping beneath the trees not as much as forest.

Dominica—

Of Dominica Mr. Sale writes—

No statistical information. 300 square miles. Heavy rainfall up to 350 inches. High mountains, four over 4,000 ft. said to be 350 rivers. Maps grossly inaccurate.

Main Rivers :—

1. Layou .. Upper part of catchment mainly forest.
2. Roseau .. Catchment area mostly deforested but much tree cultivation and some scrub. Recent (1948 ?) floods worst in history, locally believed to be due to deforestation.
3. Pegona
4. Tweed } .. East Coast catchment mainly forest.
5. Clyde

Mr. Burra writes of this Island—

Here I can speak with authority. About ¾ of the island is under forest or scrub. Catchments are still well covered but not protected (that's what I'm here for !) Shifting cultivation is rife and there's a battle ahead to see whether the Forest Service or the people win. Despite good ground cover flood and low stream flow are serious menaces.

St. Lucia—

Mr. Sale writes—

No reliable statistics. Maps unsatisfactory. 233 sq. miles. Rivers small, short and rapid, e.g., Murray, Anse la Raye, Roseau. High peaks (up to 3,000 ft.) in south

centre, rainfall over 150″. Steep slopes very liable to landslides specially after cultivation. Considerable forest on central and south central hills, but patched with illegal cultivation and charcoal burning. (Control now being much improved).

Mr. Burra has this to say of St. Lucia—

As with St. Vincent but a higher proportion of forest. Arrowroot is not the major crop as in St. Vincent, so that Soil Conservation is not such a problem. Again, however, flood and drought and diminishing returns has made the Administration realize that all is not well. Some say that "St. Lucia sold herself to Barbadoes" as there is still a flourishing cordwood and charcoal trade from the island. A great mistake.

Mr. Burra continues as follows—

Now to the Windward Islands, the Leeward Islands also Barbadoes. 1 and 2 of your Questionnaire. None of these islands has a major river and the tributaries are small streams. 3, 4 and 5. These I will bulk together. The answer is difficult as each island is compact and heavily farmed with shifting cultivation a menace.

Barbadoes—

No forest at all. Only one river which is constantly dry or in flood due to having no protected catchment. The whole of Scotland Bay area is famous to Soil Conservation students in these parts as an example of how not to treat land. Now a goat desert the only answer would be subsoil afforestation, an expensive game.

Windward Islands—

The practice has been to develop estates on the perimeter of the islands first. So, little remains within a mile to a mile and a half of the sea. Inland valleys are settled upon and shifting cultivation has played havoc on steep slopes.

Leeward Islands—

There is little virgin forest left but scrub forests are maintained to conserve water supplies in Nevis and Montserrat. Antigua has been so denuded that no water appears in wells for a large part of the year. Man made catchments are used. A ship is said to have had to bring water once. Again man has only himself to blame !

AUSTRALIA

In Australia it is admitted that a century and a half ago the first settlers found a land which appeared to be one vast forest in which the nomadic aboriginal was so primitive that he had not acquired the art of tilling the soil. 150 years later development had been so rapid that nearly all land capable of growing crops or of raising flocks and herds had been wholly or partially worked. Fortunes were made, but the misuse or overuse of the land upset the balance of Nature and their greatest national resources, soil and water, have been impaired; and owing to all failure to plan, the formerly fruitful soil has, in many cases, ceased to yield a return. An Australian has said "Erosion by wind and water, the well known 'soil-drift' has taken a great hold over considerable areas which have been turned into deserts. In the mountains overgrazing and fires have attained dimensions which endanger the catchment areas of the waterways—rivers like the Murray which are not confined to one State but on which two or three are dependent for water and irrigation. Floods are becoming more serious,

and rivers, once secure between their forested banks, are tearing away alluvial soil and bearing it down to the sea". Soil-drift and drought are now well known features in Australia.

The following is a brief account of the rivers of Australia.

New South Wales—

The Murray river, total length between NSW. and Victoria 1,200 miles; with the Darling river 1,760 miles, the latter joining the Murray river 150 miles from the South Australia border. 47 other rivers and tributaries of the Murray are over 100 miles in length.

The rivers of some importance in forestry are the Lachlan, Murrumbidgee, Snowy (NSW.), Shoalhaven, Hawkesbury, Hunter, Manning, Macleay and Clarence.

Victoria—

Murray river 1,600 miles. 14 other rivers and tributaries of the Murray river in Victoria are over 100 miles in length. Those of some forest importance being the Loddon, Goulburn, Ovena, Mitta Mitta, Glenelg, La Trobe and Snowy (Victoria).

Queensland—

Queensland is the best watered of the States. The longest rivers are the Flinders river 520 miles and the Diamantina 468 miles. There are 8 other rivers having lengths of between 300 and 400 miles and 83 more rivers and tributaries are over 100 miles in length; in addition there are a very large number of small rivers and creeks. The rivers in forest country are the Brisbane 200 miles, the Mary 165 miles and the Fitzroy 174 miles in length respectively.

South Australia—

Some 400 miles of the Murray river runs through the State and 24 other rivers of which 9 are over 100 miles in length. There are no forestry areas of importance.

Northern Territories—

The Roper river 260 miles and the Victoria river of 350 miles are the most important of the 16 rivers and tributaries of the State of which another 18 are over 100 miles in length.

Western Australia—

The longest river is the Gascoyne 475 miles with the Murchison 440 miles, the Fortescue 340 miles and the Swan river 240 miles; 25 other rivers are over 100 miles in length. Considerable savannah is found on the Swan river.

Lakes—

The lakes of Australia may be divided into 3 classes, *viz.* (*a*) true "permanent" lakes; (*b*) lakes which being very shallow become mere morasses in dry seasons, or even dry up and finally present a cracked surface of salt and dry land; and (*c*) lakes which are really inlets of the ocean, opening out into a lakelike expanse.

The second class (*b*) is the only one which seems to demand special mention. These are a characteristic of the great central plain of Australia. Some of them (e.g., Lake Torrens, Gairdner, Eyre, Frome) are of considerable extent.

Artesian Areas—

A considerable tract of the plains country of NSW. and of Queensland carries a water-bearing stratum, usually at a great depth. A large number of artesian bores have been put down, from which there is now a considerable efflux. These are of great value, and render

large areas available which otherwise would be difficult to occupy even for pastoral purposes. Western Australia has also an artesian area of considerable magnitude.

General Description of the Surface—

A section through the continent from east to west at the point of its greatest breadth, shows first a narrow belt of coastal plain. This plain extending north and south along the whole eastern coast is well watered by rivers. Of variable width, seldom more than 60 or 70 miles and occasionally only a few miles or disappearing altogether, its average may, nevertheless, be taken as about 40 to 50. From this the Great Dividing Range or Australian Highlands extending from the north of Queensland to the south of NWS. and thence sweeping westward through Victoria, rises sharply and frequently presents bold escarpments on its eastern face. The descent on its western slopes is gradual, until in the country to the north of Spencer's Gulf the plain is not above sea-level, and occasionally is even below it. Then there is another almost imperceptible rise until the mountain ranges of Western Australia are reached, and beyond these another strip of coastal plain.

The great central plain is the most distinctive feature of the Australian continent and its climatic peculiarities are doubtless to be largely ascribed thereto.

The above information is provided from extracts from the official Year Book of the Commonwealth of Australia.

Mr. G. J. Rodger, Director-General of the Forestry and Timber Bureau, Commonwealth of Australia, in this connection writes—

"It should be pointed out that many of the above rivers have very limited tree growth in their watersheds and certainly no commercial forests. Some of the rivers in the interior only flow at intervals of several years and only then as a result of above normal rainfall.

"Another important fact in relation to rivers and drainage in Australia is shown below : percentage of total land surface " :

Reference	Interior drainage	No regular surface drainage
Australia	64%	43%
Europe	24%	5%
World	33%	23%

A glance at the map of Australia, especially a forest map, shows the effect of the N. to S. Great Dividing Range on Australian Highlands extending from north of Queensland to the south of NSW. has upon the distribution of the forests. West of the barrier the forests are represented by small and comparatively scattered patches.

Mr. Rodger says on the location of forests—

"The presence of the Dividing Range adjacent to the eastern coast of Australia is one of the contributing factors in the uneven distribution of rainfall over the continent. With the exception of certain tropical areas, the principal commercial forests are mainly located in the areas of higher rainfall, e.g., along the coastal side of the Dividing Range in Queensland, NSW. and Victoria. They also occur in isolated areas in south-west Victoria, South Australia and south-west Western Australia. In Tasmania the forests are located in the extensive areas with a rainfall of from 30″ to 100″".

In consequence of the factors already discussed, most of the rivers in the forest areas are relatively short and their drainage area, in relation to the size of the continent, small. Of the Murray-Darling drainage system most is in pastoral or near desert country and only some of the headwaters are in forest country.

Mr. Rodger continues his information based on the forest map as follows—

"While the total areas of forest administered by the various State Forest Services are available by local forest districts, there are no summaries available which would include private forest areas. The best approach readily available at the moment is through the map of Australia mentioned above.

This shows :—

(*a*) Forest areas of Australia. It should be noted that this does not represent totally forested country, but merely the districts which still contain an appreciable area of forests.

(*b*) Principal rivers in forest areas, plus the Murray–Darling system, shown in colour.

(*c*) The position of the Dividing Range emphasized by a colour line.

Rivers shown on the map—

General notes follow with reference to the headwaters of the principal rivers in forestry country :

State	River	Notes
W.A.	Swan	.. Though the headwaters are not in the prime jarrah belt there is considerable savannah forest.
S.A.	Murray–400m.	.. No forested area.
Vic.	Murray–1,600m.	.. Full forest cover in the upper 100 miles.
	Loddon	.. ,, ,, 50 ,,
	Goulburn	.. ,, ,, reaches.
	Ovens	.. Appreciable forest cover in upper half.
	Mitta Mitta	.. ,, ,, over most of drainage area.
	Glenelg	.. Light forest cover.
	La Trobe	.. Forest cover in upper reaches.
	Snowy (Vic.)	.. Appreciable forest cover throughout Victorian portion.
NSW.	Murray	.. See Victoria.
	Darling	.. No forested cover on main river, but limited amount on a few of the tributaries towards the Dividing Range.
	Lachlan	.. Negligible forest cover.
	Murrambidgee	.. Forest cover in part of the upper course.
	Snowy (NSW.)	.. Variable forest cover.
	Shoalhaven	.. Appreciable forest cover.
	Hawkesbury	.. Scattered forest cover.
	Hunter	.. Main drainage basin cleared but limited full forest cover in upper reaches.
	Manning	.. Upper reaches fully covered, lower course cleared.
	Macleay	.. ,, ,, ,, ,, ,, ,,
	Clarence	.. ,, ,, ,, ,, ,, ,,

State	River	Notes
Queensland	Brisbane	.. Limited forest cover in north, very little to south.
	Mary	.. Scattered forest cover in upper reaches.
	Fitzroy	.. Light forest cover in upper reaches of Dawson Tributary.

There appears to be little doubt that the only means of arresting soil drift and drought in Australia will be to undertake serious work, based on present day forestry knowledge, on the catchment areas of the important rivers of the country.

NEW ZEALAND

In reply to my questionnaire the Director of Forestry, New Zealand, Mr. Entrican, writes—

> "I cannot give you very much, or very accurate information about the amount of forest standing at the heads of the New Zealand rivers until the National Forest Survey is complete".

The Director kindly provided a list of the chief rivers and their lengths in the North and South Islands.

North Island—

There are 10 rivers flowing into the Pacific Ocean of which the 4 longest are the Waihou (or Thames) 90 miles, Rangitaiki 95 miles, Mohaka 80 miles, and Ngaururoro 85 miles. Ten more flow into Cook Strait of which the longest are the Manawatu 100 miles, Rangitikei 115 miles, Wanganui 140 miles and Wangaehu 85 miles. And five others flow into the Tasman Sea the longest being the Waikato 220 miles and Wairoa 95 miles.

South Island—

Flowing into the Pacific Ocean in the South Island there are 19 rivers, 8 of which are 90 miles and over in length. The names of these rivers are Clarence 125 miles, Waiau-uha 110 miles, Hurunui 90 miles, Waimakariri 93 miles, Rakaia 95 miles, Waitaki 135 miles, Taieri 125 miles and the Clutha 210 miles. Four rivers flow into the Foveaux Straits : Mataura 120 miles, Oreti 105 miles, Aparima 65 miles and the Waiau 115 miles. Lastly, 19 rivers flow into the Tasman Sea. These are mostly rivers of short length, 15 of which are under 50 miles in length ; 4 rivers of 50 miles and over are the Hollyford 50 miles, Haast 60 miles, the Grey river 75 miles and the Buller river 105 miles.

TASMANIA

A most interesting communication was received from Tasmania from the Chief Commissioner of the Forestry Department, Mr. A. H. Crane, on the subject of the forested areas on the main rivers of Tasmania, a country, which from the forestry viewpoint, is little known in many parts of the world.

> "It has not been possible", says the letter, "to give the areas of forests or the separate tributaries of the main rivers but only the very approximate forested areas of each main river catchment. Forested areas also include those areas where logging is in progress or which have been logged in the past".

River	Total length miles	Total catchment sq. miles	Forested area sq. miles	Tributary	Length in miles
Derwent ..	120	4,006	1,440	Jordan	55
				Clyde	45
				Ouse	64
				Nive	40
				Florentine ..	35
				Russell Falls ..	18
				Styx	28
				Plenty	20
South Esk ..	110	2,810	774	Meander	30
				Lake	55
				Macquarie ..	60
				Elizabeth ..	30
				St. Pauls ..	33
				Tyne	12
				Nile	30
Gordon ..	95	1,882	806	Olga	16
				Serpentine ..	22
				Boyd	12
				Gell	12
				Denison	31
				Maxwell	19
				Franklin ..	45
Huon ..	94	1,312	480	Russell	10
				Little Denison ..	8
				Weld	27
				Craycroft ..	18
				Picton	30
				Arve	13
Pieman (Huskisson)	80	1,491	966	Murchison ..	34
				Macintosh ..	18
				Wilson	20
				Stanley	15
				Savage	22
				Donaldson ..	23
Arthur ..	85	998	813	Frankland ..	45
				Rapid	30
				Eastern Creek ..	28
				Hellyer	20

(*contd.*)

River	Total length miles	Total catchment sq. miles	Forested area sq. miles	Tributary	Length in miles
Mersey ..	90	717	147	Dasher	20
				Fish	16
				Fisher	16
Ringarooms ..	55	346	237	Dorset	12
				Wyniford ..	11
Tamar Estuary ..	40	538	77		
North Esk ..	38	390	256	Ford	10
				St. Patricks ..	20
Forth ..	60	480	179	Wilmot	32
				Dove	16
		14,970	6,175		
Coastal Rivers ..		8,595	2,810		
TOTALS ..		23,565	8,985		

"Logging in Tasmania is usually on a single tree and/or small group selection basis except that on some of the *Eucalyptus regnans* forests small areas are clear felled. Tasmanian eucalypt forests usually commence to regenerate naturally within two years of felling or damage by fire".

(*continued*)

THE APPLICATION OF SELECTIVE HERBICIDES TO FORESTRY PRACTICE

BY T. N. SRIVASTAVA

PART II

HISTORICAL REVIEW

Major developments in the technique of controlling low value hardwoods on a large scale have occurred only within the last 25 years. An outstanding example of the earlier type of work was the eradication of *Ribes* spp. in the control of white pine blister rust (*Cronartium ribicola*) (Offord *et al* 1940 ; Joy 1942 ; Craig 1946).

With the discovery of selective herbicides, particularly the growth substances, large scale investigations have been begun to test the differential toxicity of the various herbicides on different woody plant species. Day (1947-a) experimenting on the control of hazel (*Corylus sornuta*), pincherry (*Prunus pennsylvanica*), alder (*Alnus incana*), mountain maple (*Acer spicatum*) and willow (*Salix* spp.) reported that ammonium sulphamate was most effective on hazel but that the other species sprouted strongly after treatment. He also found that 2, 4-D was most effective on hazel but least effective on mountain maple. Jones (1945), while testing various chemicals on woody shrubs, found that 2, 4-D and 2, 4, 5-T were the most effective chemicals for poison ivy (*Rhus toxicodendron*), Hammer and Tuckey (1946), demonstrated that 2, 4-D killed several other woody shrubs and trees like Elm (*Ulmus americana*) and cherry but had no effect on the common juniper (*Juniperus communis*). Hanson (1947) reported that 2, 4-D spray adversely affected black walnut trees (*Juglans nigra*). Several tree species such as bur oak (*Quercus macrocarpa*) and white ash (*Fraxinus americana*) were found by Dutton (1947) to be equally resistant to 2, 4-D and 2, 4, 5-T, but Tamm (1947) studying the comparative herbicidal properties of 2, 4-D and 2, 4, 5-T found that on herbaceous and semi-woody species 2, 4-D was either greater or equal to 2, 4, 5-T in toxicity whereas on woody shrubs and trees 2, 4, 5-T was definitely more toxic. Neville and Willard (1947) also found that 2, 4, 5-T was more toxic to *Populus deltoides* than the 2, 4-D.

Recently success in the control of weeds by selective herbicides has also been achieved in forest regeneration areas and plantations. Day (1947-b) found that an oil solution of D.N.B.P. when sprayed on to the trunks of sapling size aspen growing among pines, killed the aspen without injuring the pines, though he stresses that care should be taken not to spray the pines directly.

Zehngraff (1948-a, b and c and 1949), carried out several experiments on the control of woody and herbaceous weed growth in forest plantations and natural regeneration areas. The areas treated were a newly established plantation of red pine, a natural white pine reproduction area covered with heavy brush growth and a fresh site for the preparation of plantations. Aqueous solutions of Amm. sulphamate (Ammate) and 2, 4-D showed promise as a means of effective control of noxious woody plants without injuring the pines and at a comparatively low cost. 2, 4-D was found better than the ammate, since the latter did not check sprouting and was comparatively more injurious to the pines. In the tropics very little work has been done so far in selective herbicidal methods of weed control.

Experiments carried out at Dehra Dun, India, from 1934 to 1941 Griffith (1941) have shown that Lantana (*Lantana camera*) could be controlled successfully and cheaply by the application of a sodium chlorate spray and the concentration required to kill the Lantana had

no toxic effect on subsequent regeneration of the area ; but again, the use of the chemical in this case was not strictly on selective principles.

In Hawaii, sodium penta-chlorophenate and 2, 4-D have been found beneficial in the control of weeds in pine apple and coffee plantations (Von Overbeck and Ismael 1946 ; Sherwood 1947).

USE IN FOREST NURSERIES

The use of chemicals to control weeds in forest nurseries is not new. As far back as 1920, Kitchen found that sulphuric acid and zinc sulphate reduced weed development in nurseries without injuring coniferous seedlings. Stevens (1928) observed that a one per cent solution of copper sulphate also decreased weed growth whilst Juhlin-Damnfelt (1925 and 1927) in Sweden, noted that zinc sulphate decreased weed growth by 50–75% without injuring pine and spruce seedlings. Toumey and Li (1924) confirmed Kitchen's observations on sulphuric acid but Wahlenberg (1930) reporting on zinc sulphate was not very optimistic. Olson (1930), while recommending that chemicals could be used for weed control in the forest nurseries, stressed that they should be used with care.

It appears that the results of earlier investigations, though satisfactory in certain respects, were not sufficiently practical for use on a large scale and hence little progress was made until the increasing costs and shortage of labour during the war necessitated renewed efforts.

Robbins *et al* (1947) while testing the suitability of various selective herbicides on coniferous seed beds and transplant rows, found that Stanisol (an oil fraction) was most effective in the control of weeds without harming the seedlings, but they also noticed some differences in the tolerance of the various species to the herbicide and suggested further experiments before using it on a large scale.

From 1944 to 1946 a wide variety of chemicals have been tried on almost all the weed species of southern pine seed beds in America. Cossitt (1947 and 1948) reported some remarkable results with the mineral spirits but he again found that the selectivity of the chemicals was dependent upon various factors such as the age of the seedlings, soil moisture, temperature and the amount of the spray applied, and suggested further investigations. Success with the oils has aslo been reported by Stoeckeler (1948), Anon. 1948 and Eliason (1949). They found that oil sprays, applied several times during the growing season, gave promise of reducing weeding costs in coniferous nurseries as much as by 50 to 80 per cent. The oils used were Sovasol No. 5, Stanisol, Varsol, Stoddard solvent and mineral spirits, and were applied at the rate of 30 to 120 gallons per acre. Rates above 120 gallons an acre were considered by Stoeckeler (1948) to be injurious to coniferous seedlings and he further suggested that there was less chance of injury to evergreens if spraying was done on reasonably cool days. Eliason (1949) on the other hand, concluded that the evergreen coniferous species were generally highly tolerant to oil sprays but that deciduous species like larch were very susceptible. He also noted that many species of weeds resistant to frost were also resistant to oil sprays and that the appearance of the killed plants was similar to that of frost killed ones. All these workers report a high susceptibility of broadleaved species to oils thus precluding the use of such oils in beds of such species.

Growth substances have also been tried to control weeds in coniferous nurseries and, though some success has been reported (Beatty and Jones 1945 ; Johnson 1947), more investigations are necessary before any definite conclusions can be drawn.

In Britain, investigations on the effects of selective herbicides on tree species have so far been confined to nurseries. Only during the present year has it been proposed to begin

experiments on the control of coppice and scrub growth in derelict woodlands. Investigations by Sanzen Baker and Templeman (1947) on the suitability of M.C.P.A. for seed beds of Scots pine and European Larch and transplant lines of the latter, showed that concentrations up to 5 lb. per acre, applied at the time of sowing, had no marked deleterious effect on Scots pine seedlings whereas a considerable saving in the weeding time was effected. They found that treatment of the beds after the establishment of weeds was much less effective in the control of weeds and more deleterious to the tree seedlings. They also observed that the powder form was better in the pre-emergent treatments and that the solution was more suitable for the post-emergent stage, the solution being less toxic to tree seedlings. Larch, however, suffered heavy casualties in all the treatments and at the lowest concentrations.

The Forestry Commission of Britain in collaboration with the Agricultural Research Council, Oxford, started experiments in 1948. The general aim of these investigations was to determine the toxicity of a range of selective herbicides on various coniferous species and thus to estimate their suitability for weed control in forest nurseries. Some preliminary observations have been made and further work is in progress. The experiments carried out by the author in the course of this study form part of this general investigation.

EXPERIMENTS

Although some work on the technique of pre-emergent herbicidal treatments has been done in the Agricultural field no studies appear to have been made along these lines with forest trees. In view of the importance attached to the development of such a technique in forestry practice, a number of experiments were set out to study the effects of various herbicides on the germination of seeds of certain tree species in the laboratory. These investigations were later supplemented by further experiments on the effects of a range of herbicides on the post-germination stages of conifers grown in pots and nursery beds.

The work was started in November 1948. Laboratory experiments were carried out at the Department of Agriculture and field experiments at Kennington Nursery, Oxford.

A. LABORATORY EXPERIMENTS

Object.—The object of these experiments was (1) to study the effect of various selective herbicides on the germination of seeds of tree species and (2) to make a comparative assessment of the toxicity at L.D. 50 (concentration of the chemical which will inhibit normal germination of 50 per cent of the seeds) for each species and chemical used.

Materials.—Chemicals used were Na.M.C.P.A., Na.D.C.P.A., T.C.P.A. and I.P.C. and were supplied by the Agricultural Research Council, Oxford (for details of properties cf. Appendix 1).

Seeds were obtained from the Kennington and Alice Holt nurseries and requests were also made to authorities abroad, viz., the United States of America for pine seeds and Sudan and India for seeds of tropical species. Seeds of about 30 species were thus collected from different sources and tested for germination, those giving a fair percentage of germination being used in subsequent investigations.

Technique.—For the preliminary germination tests, seeds were placed on moistened filter paper laid in petri dishes and kept in an incubator at 23°C. This temperature was found more suitable than 30°C, which was also tried. Considerable difficulty was experienced in obtaining a satisfactory germination of coniferous seeds during the winter season. Various methods, such as soaking the seeds in water for 24 to 72 hours or soaking in hot water till it cooled, were tried, with but little success. The rate of germination improved with the

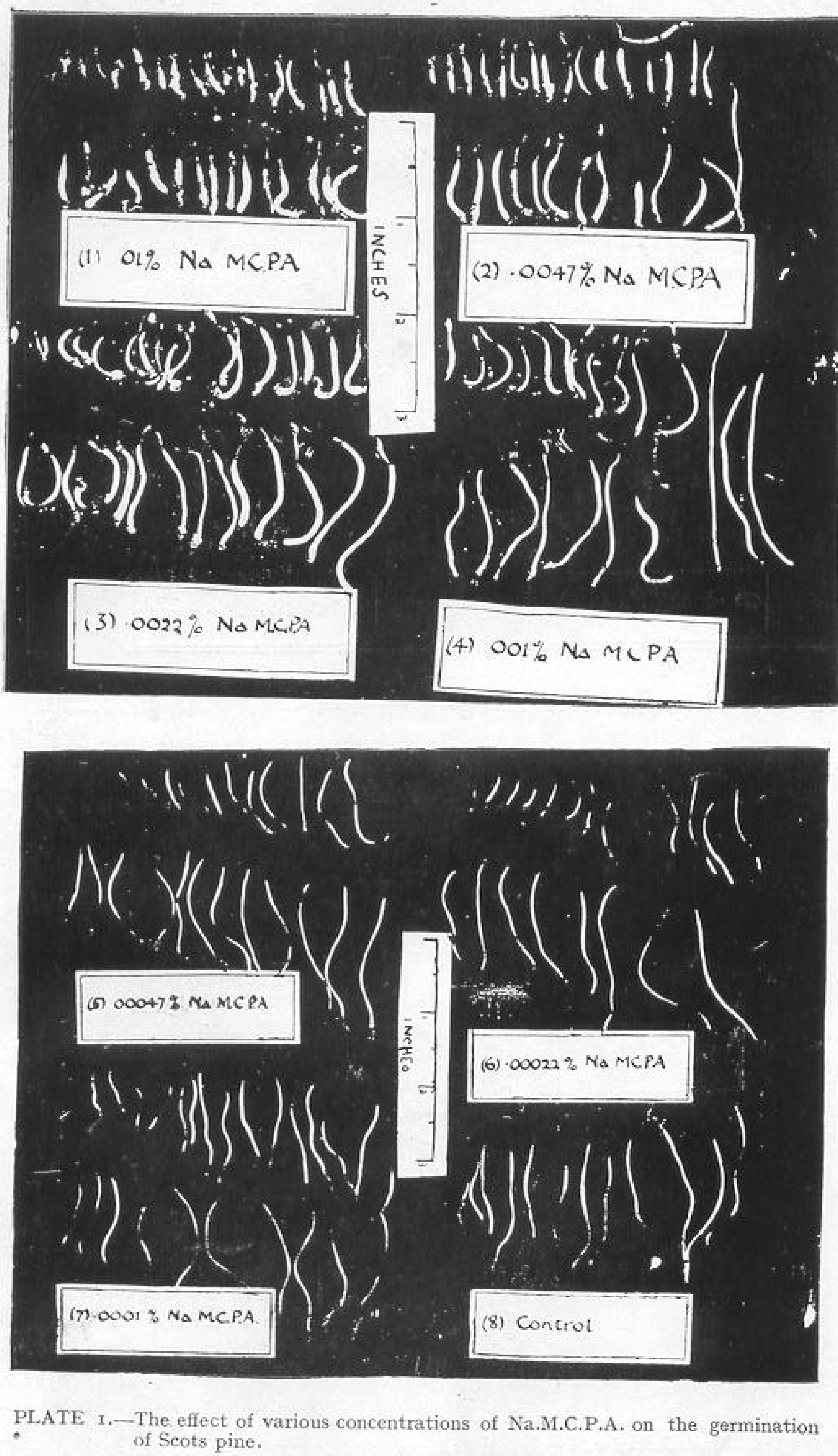


PLATE 1.—The effect of various concentrations of Na.M.C.P.A. on the germination of Scots pine.

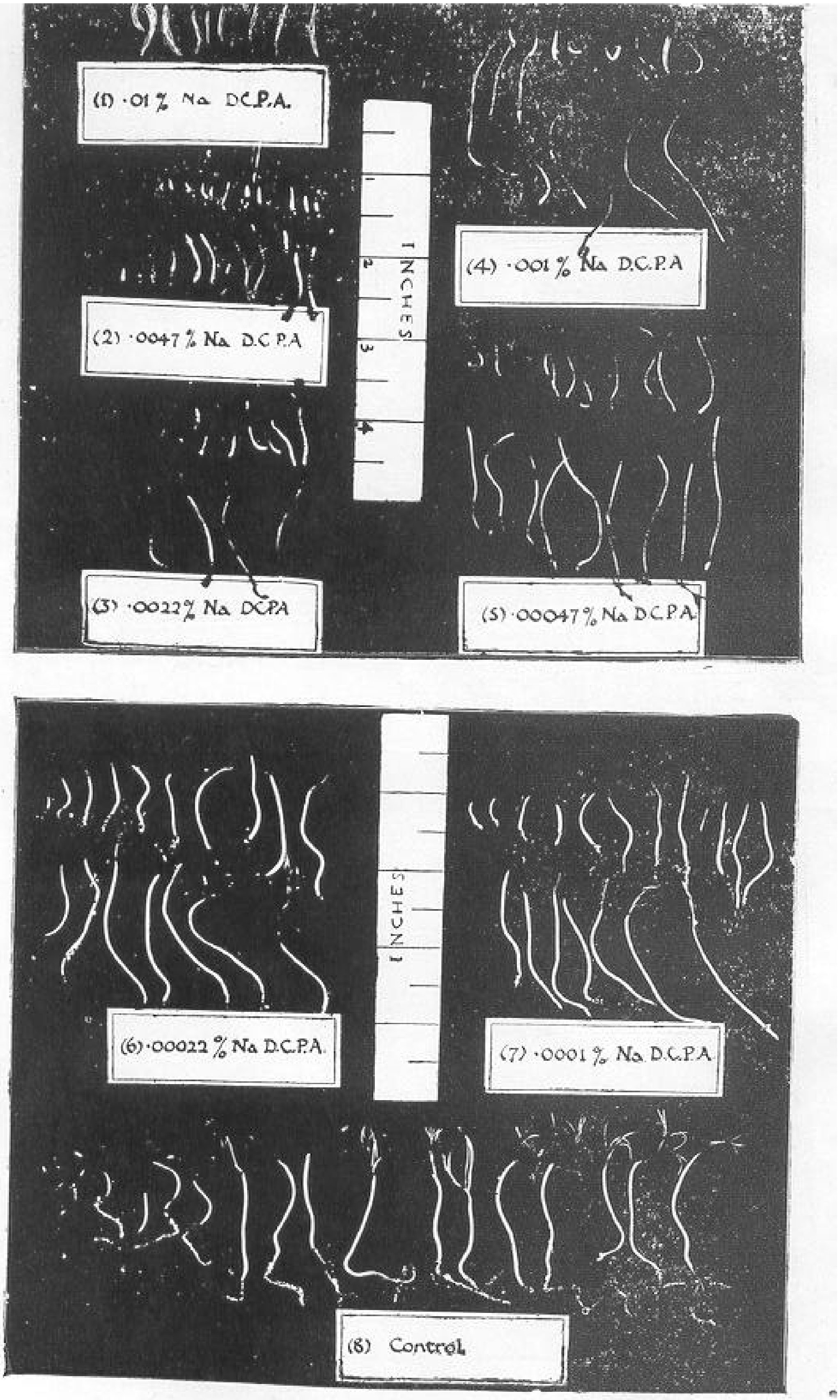


PLATE .—The effect of various concentrations of Na.D.C.P.A. on the germination of Scots pine.

approach of the spring season. No definite reason could be attributed to this phenomenon except that the seeds, which did not germinate well, were probably in a dormant state, as often is the case with many coniferous seeds. Some of the seeds showed infection by fungi during incubation which was probably due to the presence of spores in the seeds and thus another possible reason for low germination. The species which germinated well were :—

Species		*Source of Seed Supply*
Pinus sylvestris	.. (Scots pine)	Alice Holt and Kennington nurseries, Oxford.
Pinus contorta	.. (Beach pine or Shore pine)	
Pinus radiata	.. (Monterey pine)	
Pinus austriaca	.. (Austrian pine)	
Picea excelsa	.. (Norway spruce)	
Pinus banksiana	.. (Jack pine)	Lake States Experimental Station, Minnesota, U.S.A.
Pinus resinosa	.. (Red pine or Norway pine)	
Pinus strobus	.. (White pine)	
Pinus attenuata	.. (Knobcone pine)	Institute of Forest Genetics, Placerville, California.
Acacia catechu	.. (*khair*)	India.
Acacia modesta	.. (*phulai*)	

The usual technique adopted with phytocidal germination tests is that of germinating seeds on filter paper and treating the seeds with aqueous solutions of the toxicants. A measure of response is then obtained by counting the number of germinated seeds. The method is simple but has a number of drawbacks such as (1) difficulty in deciding a standard for distinguishing between germinated and ungerminated seeds with a satisfactory degree of accuracy, (2) difficulty in the application of herbicides not sufficiently soluble in water. To overcome these difficulties, silver sand was used as the medium for germination and the chemicals were applied to the sand. Ordinary sifted gravel was also tried and, though it did not show any adverse effect, silver sand appeared to give better results. The gravel also dried earlier in the incubator and thus proved rather unfavourable for coniferous seeds which take a long time for germination.

The chemicals were applied at concentrations of ·1 to ·0001 per cent (1000 p.p.m. to 1 p.p.m. of the solvent) on a logarithmic scale which gave a fairly wide range for the purposes of these experiments. Na.M.C.P.A. and Na.D.C.P.A., which are soluble in water, were applied as aqueous solutions, while I.P.C. and T.C.P.A., which have only a limited solubility in water, were applied as acetone solutions.

9 c.m. petri dishes were used for the experiments and the first step was to find out a suitable quantity of sand and solution to be used per dish, to obtain successful germination. The depth of a 9 c.m. petri dish is about 5/10″ to 6/10″ and when 75 gms. of silver sand were spread in them it gave a layer of an average 2/10″ thickness, leaving about 3/10″ free space at the top. This space was considered sufficient to allow for the growth of the seedlings and it was, therefore, decided to use 75 gms. of sand per dish.

To find out the quantity of solution to be added per 75 gms. of sand, the moisture content of the sand in the saturated condition was found by the ordinary weighing method. This came to 20·6 per cent by weight or 15·45 c.c. per 75 gms. of sand. It was considered safe to use about 75 per cent of this quantity of moisture for the germination tests, i.e., 10 c.c. of

solution per 75 gms. of sand. The sand was sterilized in an oven at 100°C for 24 to 48 hours before use to prevent fungal growths and moulds during incubation. It was also found stimulating to germination to use moderately warm sand in the dishes.

Owing to their different solubilities the technique applied in the I.P.C. and T.C.P.A. treatments was different from that for Na.M.C.P.A. and Na.D.C.P.A.

Na.M.C.P.A. and Na.D.C.P.A. treatments.—Sand from the oven was allowed to cool for a few minutes then weighed in lots of 75 gms. and spread in the dishes to be sown. 50 seeds per dish were considered sufficient and 2 to 3 replicates per concentration were used. About half the quantity of sand was spread at the bottom and half was used to cover the seeds, but, in the case of very small seeds it was found beneficial to use $\frac{3}{4}$ of the sand at the bottom and only $\frac{1}{4}$ as the top covering. Solutions were then added with a pipette as evenly as possible and the dishes placed in the incubator. A slight uneven distribution of chemical at the beginning did not matter as it was remedied when the dishes were placed in the incubator and the sand absorbed the moisture.

I.P.C. and T.C.P.A. treatments.—The chemicals were dissolved in acetone. The required quantity of oven dry sand was then treated in lots with the appropriate quantity corresponding to each concentration of chemicals, mixed well, and spread on cardboard dishes for about 24 hours for the acetone to evaporate. After the acetone had evaporated, 75 gms. of sand for each dish was weighed out and seeds sowed as above. 10 c.cs. of water were then added to each dish and the dishes placed in the incubator. An acetone control, i.e., sand treated with pure acetone was also used in the preliminary experiments but as the acetone did not appear to have any effect on germination this control was discarded in the final tests. The acetone evaporates quickly and appears to leave no toxic residue.

Observations.—Two sets of experiments had to be performed for each species with each chemical. The preliminary test consisted of finding out the approximate limits of concentration between which L.D. 50 would lie. This was done by using ·1%, ·01%, ·001% and ·0001% solutions. The final test was then made by dividing the approximate range into closer concentrations to obtain a more accurate figure.

Germinated seeds were counted periodically until a constant figure in the controls was reached, when the dishes were taken out of the incubator and the final count made. This took about 15–20 days for the complete germination of coniferous seeds.

The original idea of counting only those seeds as germinated which emerged through the sand was not found satisfactory and considerable difficulty was experienced in distinguishing between germinated and ungerminated seedlings. It would not be justifiable to say that only those seedlings which emerged through the sand should be counted as germinated. In many cases quite a few seedlings spread along the bottom of the dish, grew to a good length, but never emerged above the sand, and yet must be included among the germinated seedlings. An additional difficulty arose since, of the seedlings which germinated and emerged above the sand, many were abnormal and many died before attaining an appreciable length (cf. accompanying photographs). In order to obtain some measure of the extent of germination, however, it was decided to fix an arbitrary length of 1″ and over as constituting a germinated seedling. This decision was supported by the fact that in the vast majority of cases, particularly at the higher concentrations, seedlings which did not attain this length were abnormal or actually died. Allard, De Rose and Swanson (1946) experienced similar difficulties in the germination of cereal seedlings and thus could not assign values of germination percentage in their results.

Germination figures for each concentration were adjusted in relation to the control mortality and converted into probits. The probit figures were then plotted against log concentrations of the chemicals used and L.D. 50 was determined from the probit lines. By means of

such probit conversions, normal sigmoid curves may be transformed into straight lines thus facilitating a more accurate determination of L.D. 50 and the comparison of different mortality curves. In some cases the resulting probit lines were not very satisfactory but, since quite good sigmoid curves were obtained when the germination figures were plotted against the log concentrations, L.D. 50 was determined directly from the sigmoid curves themselves. The results are tabulated below :—

TABLE I

Species	L.D. 50 (p.p.m.)		T.C.P.A.	I.P.C.
	Na.M.C.P.A.	Na.D.C.P.A.		
Pinus sylvestris (Scots pine) ..	11	12	18	100
Pinus banksiana (Jack pine) ..	11	5	11	74*
Pinus resinosa (Norway pine) ..	14	6	11	38*
Pinus contorta (Beach pine) ..	7	(1½)*	—	47
Pinus strobus (White pine) ..	7½	4½	—	—
Pinus radiata (Monterey pine) ..	—	6	—	—
Pinus austriaca (Austrian pine) ..	19	—	—	—
Pinus attenuata (Knobcone pine) ..	(6)	(9)	—	—
Picea excelsa (Norway spruce) ..	9	8	25	59*
Acacia modesta (*phulai*) ..	(6)	(2½)	—	—
Acacia catechu (*khair*) ..	6½	3½	2	107*

NOTE :—* = figures determined from the sigmoid curves.
( ) = figures based on relatively low germination percentage of seeds.
— = not tried.

Analysis of data.—From the inspection of the figures given in the table above and the probit lines (of Appendix II, graphs 1 to 12) the following conclusions may be drawn :—

(1) Na.D.C.P.A. appears to be more toxic than Na.M.C.P.A. to all species except *Pinus sylvestris* and *Pinus attenuata* (cf. Appendix II, graphs 1 to 9).

(2) To all species I.P.C. appears to be much less toxic than the phenoxy-acetic acids.

(3) The phenoxy-acetic acids appear to be more toxic to broadleaved tropical species, viz., *Acacia catechu* and *Acacia modesta* than to the coniferous species, while I.P.C. shows almost the reverse behaviour.

(4) A comparison of the L.D. 50s shows that *Pinus austriaca* was more resistant to Na.M.C.P.A. than were the other species. Next in order of immunity to Na.M.C.P.A. comes *Pinus resinosa*, while the differences in the susceptibility of the other coniferous species are not very great. Further, a comparison of the probit lines (cf. Appendix II, graph 10) shows a much steeper slope for *Acacia catechu* and *Pinus resinosa* than for the other species. This indicates that the seeds of these two species are less variable in their resistance to the chemical than are the other species, so that, although the differences between the L.D. 50s for these and the other species may not be great, a much greater difference in their susceptibilities may be expected when the L.D. 20s or L.D. 100s are compared ; so much so that the order of relative toxicity may even be

reversed. For example, at L.D. 50, *Pinus resinosa* is more resistant to Na.M.C.P.A. than *Pinus sylvestris* or *Pinus banksiana* whereas at L.D. 100, the latter species appear to be more resistant than *Pinus resinosa*.

Not only is this phenomenon of academic interest but it may prove to be of considerable importance in practical studies on selective methods of weed control, since the aim of such studies is not necessarily the determination of an arbitrary figure like L.D. 50 but rather the assessment of the toxicity to tree species of a particular concentration of herbicide which is found to kill weeds.

(5) Except in the case of the Acacias, *Pinus sylvestris* and *Pinus contorta*, the species investigated show little difference in their susceptibility (at L.D. 50) to Na.D.C.P.A. It is, however, interesting to note that *Pinus resinosa* and *Pinus radiata*, both of which show the same L.D. 50, reveal quite a different slope in the probit lines, indicating a higher variability in the susceptibility of *Pinus resinosa* seeds than that of *Pinus radiata* seeds (cf. Appendix II, graphs 11).

(6) The effect of T.C.P.A. appears to be very variable. A comparison of L.D. 50 figures shows that it is more toxic than Na.M.C.P.A. and Na.D.C.P.A. to *Acacia catechu* but less toxic in the case of *Pinus sylvestris* and *Picea excelsa*. In the case of *Pinus resinosa* and *Pinus banksiana* it is again less toxic than Na.D.C.P.A. but in these cases there is very little difference between it and Na.M.C.P.A. There is no difference between the L.D. 50s for *Pinus resinosa* and *Pinus banksiana* but the probit lines of these species show different slopes which indicates that at lower concentrations *Pinus resinosa* seeds are much more resistant than are the *Pinus banksiana* seeds (cf. Appendix II, graph 12).

(7) I.P.C. shows a wider variability in its toxicity to various species than do the phenoxy-acetic acids.

(8) It is interesting to note that in all the three cases, i.e., probit lines for Na.M.C.P.A., Na.D.C.P.A. and T.C.P.A. (cf. Appendix II, graphs 10, 11 and 12) *Acacia catechu* and *Pinus resinosa* show a characteristically steeper slope than do the other species. This suggests that the seeds of these two species are less variable in their reaction to these chemicals than are the seeds of the other species.

Some general observations, which were made on the responses of the germinating seedlings to the herbicides, were considered interesting and are, therefore, given below :—

(1) Increasing concentrations retarded the rate of germination and decreased the number of seeds which germinated.

(2) In some cases germination and seedling development appeared to be stimulated by the lower concentrations (about 1 p.p.m. to 5 p.p.m.) of the chemicals used (both Phenoxy-acetic acids and I.P.C.).

(3) Higher concentrations of Na.M.C.P.A., Na.D.C.P.A. and T.C.P.A. caused swelling of both the hypocotyls and the roots, particularly in the region of the root-hypocotyl junction. At concentrations above ·01% several seeds swelled up enormously, the testa was ruptured and the endosperm exposed. This endosperm was sometimes split longitudinally showing the young embryo which, however, did not develop. This swelling was not exhibited in the I.P.C. treatments (cf. accompanying photographs).

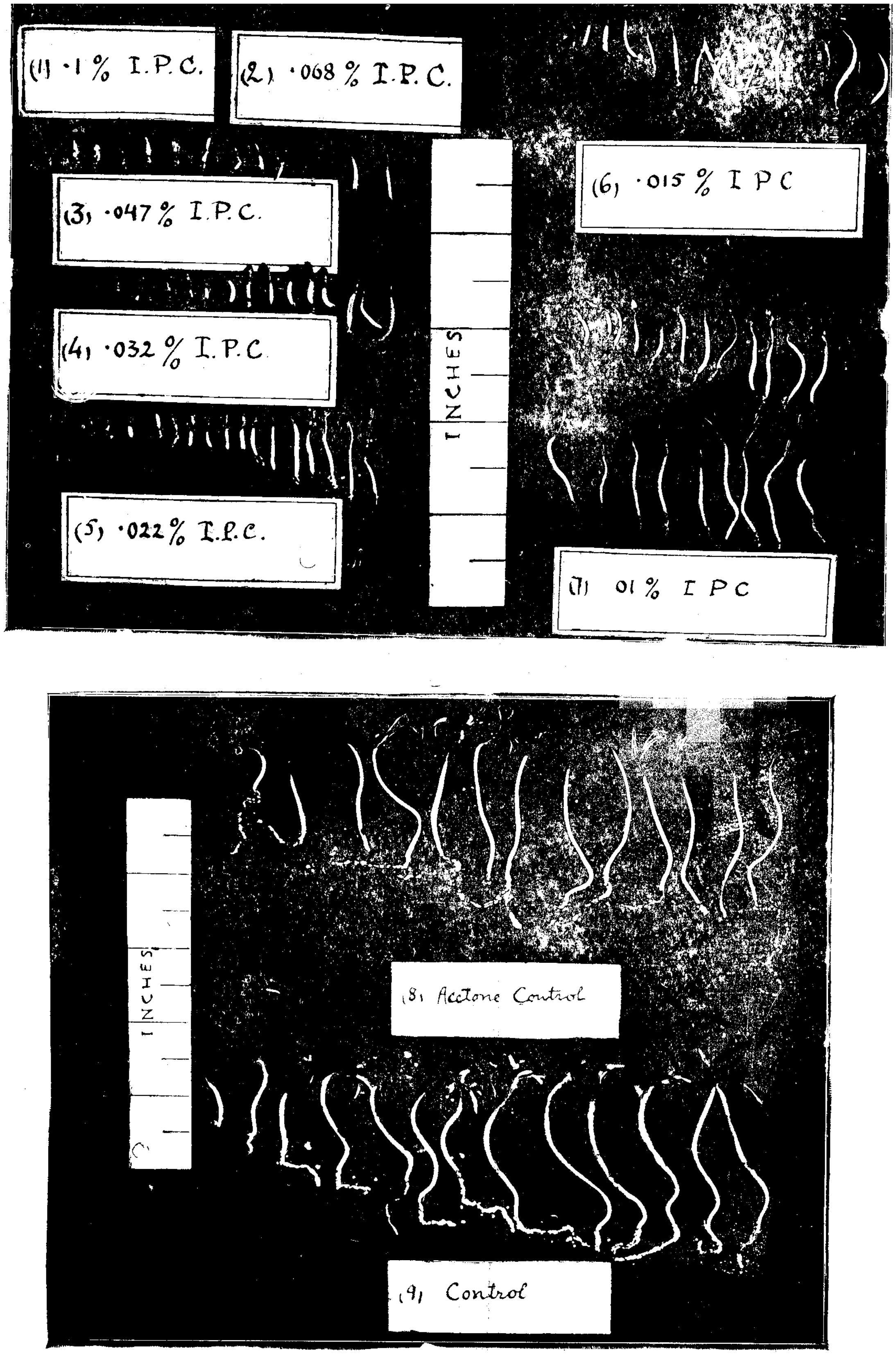


PLATE 3.—The effect of various concentrations of I.P.C. on the germination of Scots pine.

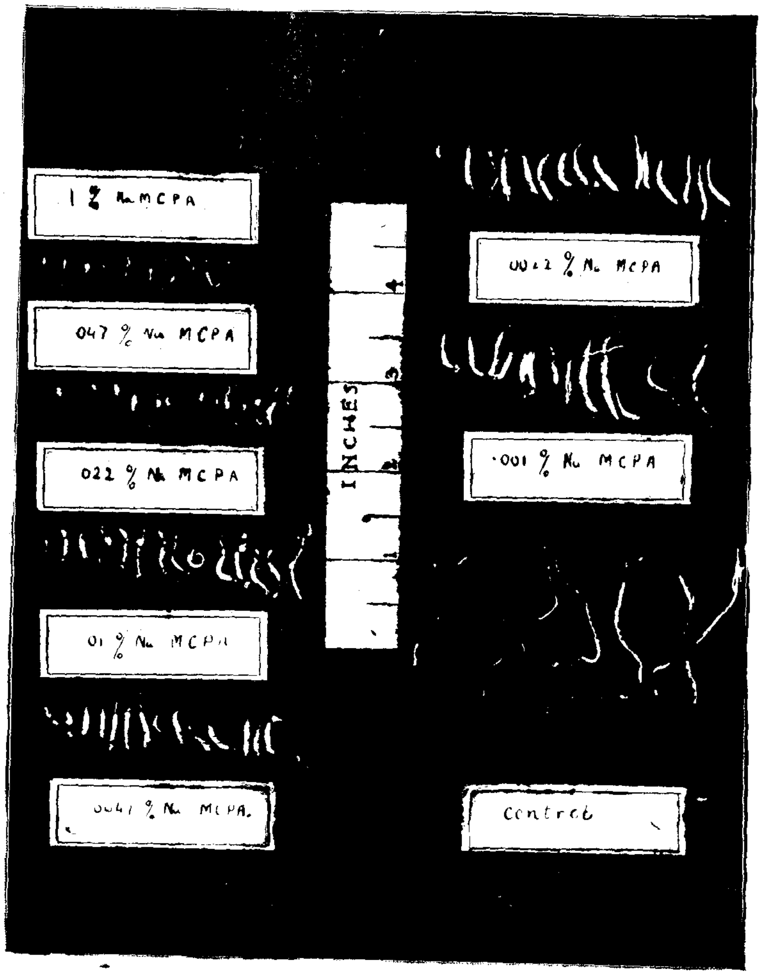


PLATE 4.—The effect of various concentrations of Na.M.C.P.A. on the germination of Norway spruce.

(4) The growth of the primary root and the formation of lateral roots was retarded even by the lowest concentration (1 p.p.m.) of Na.M.C.P.A., Na.D.C.P.A. and T.C.P.A., but in the case of I.P.C., inhibition of root growth generally started above the 10 p.p.m. concentration (cf. photographs for Na.M.C.P.A. and Na.D.C.P.A.).

(5) Inhibition of root and shoot growth increased with the increase in concentration and roots were found to be more sensitive than the shoots (cf. photographs).

(6) In the case of several species, at the higher concentrations, roots showed what appeared to be a negative chemotrophic response by emerging upwards away from the medium instead of growing down into the sand. The seedlings did not develop and died in that position.

(7) At the highest concentration used (·1%) development of the primary root was almost completely inhibited. The testa ruptured and the radicle emerged but did not grow ; many seeds died even without breaking the testa.

(8) In general the chlorophenoxy-acetic acids were found more toxic than I.P.C. At ·01% concentration definite signs of toxicity, viz., inhibited, crooked and malformed growth, were visible in the case of phenoxy-acetic acids but in the case of I.P.C. a similar effect was observed only at concentrations higher than ·01%.

(9) No threshold concentration above which the emergence of seeds was totally inhibited was apparent, though the ·1% concentrations showed marked toxicity in all cases and might be considered as the lethal dose.

It is interesting to note that Allard, De Rose and Swanson (1946) made similar observations in their experiments.

B. NURSERY EXPERIMENTS

Two sets of experiments were planned :—

I. Seedlings grown in pots.
II. Seedlings grown in seed beds.

The object of the pot experiments was to test as large a number of chemicals as possible for a preliminary assessment of their effect on coniferous seedlings while the object of the bed experiments was to study in more detail the effect of certain oils on the same species.

Material.—The species chosen for the experiments were :—

1. Scots pine (*Pinus sylvestris*).
2. Sitka spruce (*Picea sitchensis*).
3. Japanese larch (*Larix Kæmpferi*).

Seeds were supplied by the Forestry Commission (Alice Holt). Care was taken to use seeds of the same specification as used in other experiments laid down by the Commission to facilitate future comparison of results.

The following chemicals were used and were obtained from the Agriculture Research Council, Oxford. (For properties of the chemicals cf. Appendix I).

Inorganic compounds

1. Ammonium sulphamate.
2. Sodium thiocyanate.

Organic compounds

1. Potassium ethylxanthate.
2. Ammonium dinitro-secondary-butyl phenol (Amm. D.N.B.P.).
3. Sodium pentachlorophenate (Na.P.C.P.),

Growth substances

1. Sodium salt of M.C.P.A. (Na.M.C.P.A.).
2. ,, ,, ,, D.C.P.A. (Na.D.C.P.A.).
3. ,, ,, ,, T.C.P.A. (Na.T.C.P.A.).

Oils

1. Esso vaporizing oil.
2. Regent vaporizing oil.
3. Shell T.P. 711.
4. Anglo Iranian white spirit W8/72.
5. Varsol.
6. Diesel oil.

Oil extracts

1. Extract No. W8/395.
2. ,, ,, W8/409.
3. Shell H-10.
4. Extract No. W8/404.

The oils mentioned above are representative petroleum fractions which have been tested as selective herbicides. Vaporizing oils are in general more toxic than white spirits and heavier oils like diesel oil are even more toxic, but less selective. It was, therefore, decided to use oils of all these three categories in the experiments.

The extracts, such as mentioned above, are obtained as residues after purification of the oils. They possess high contents of aromatic compounds which are known to be particularly toxic to plant growth. Such extracts as were used were, therefore, diluted with odourless kerosene which has a very low aromatic content.

I. Pot Experiments

Treatment.—The various treatments applied to the seedlings were as follows :—

a. *Inorganic, organic and growth substances*	*Concentrations*
1. Amm. sulphamate	1·0 ; 2·0 ; 4·0%
2. Sodium thiocyanate	1·0 ; 2·0 ; 4·0%
3. Pot. ethyl xanthate	0·5 ; 1·0 ; 2·0%
4. Amm. D.N.B.P.	0·1 ; 0·2 ; 0·4%
5. Na.P.C.P.	0·5 ; 1·0 ; 2·0%
6. Na.M.C.P.A.	0·1 ; 0·2 ; 0·4%
7. Na.D.C.P.A.	0·1 ; 0·2 ; 0·4%
8. Na.T.C.P.A.	0·1 ; 0·2 ; 0·4%

No replicates were introduced as only a preliminary indication of toxicity was required. The above concentrations were used because they cover the range required for killing many weeds, the middle concentration being considered as the most efficient.

b. *Straight oils*

These were used pure without dilution. Each treatment was replicated twice.

c. *Oil extracts*

Three concentrations, viz., 10%, 17·5% and 25% of the extracts in odourless kerosene were used and the treatments replicated twice.

In all cases the chemicals were applied at the rate of 100 gallons per acre and at 40 lb. pressure.

Technique.—Ordinary 10″ garden flower pots filled with nursery soil and a top-layer of about 1″ of compost were used. Sixty-six pots were sown with each species to provide for all treatments and controls. After sowing a layer of silver sand was sprinkled over the seeds as this facilitates germination. Care was taken to sow equal quantities of seeds to obtain as far as possible an equal number of seedlings in each pot. The sowing was done on March 18, 1949, at Kennington Nursery, Oxford. The weather following the sowings was extremely dry and the pots had to be watered occasionally. Japanese larch and Scots pine germinated earlier than Sitka spruce which showed no signs of germination until about April 20, 1949, Unfortunately, the original stock of Scots pine seedlings was almost completely destroyed by birds and a supplementary sowing was made on April 27, 1949. Pots were weeded once as soon as weeds were found interfering with the seedlings, the object being to study the effect of chemicals on tree seedlings and not on the weeds.

The chemicals were sprayed when most of the seedlings were in the young true leaf stage, but due to the irregularity of germination quite a number of seedlings in the cotyledonary stage and some with the seed coat still on were also present. The height of the seedlings was, on the average, 1″ to $1\frac{1}{2}$″.

Japanese larch was sprayed about 9 weeks after sowing but Scots pine, due to casualties, and Sitka spruce, due to slower germination, were not ready for spraying until about 11 weeks after sowing. Spraying was done in the green-house at the Department of Agriculture by means of a special apparatus designed for the purpose and the pots were retained in the green-house for 24 to 28 hours before transporting them back to the open. The weather at the time of spraying was bright and warm as a result of which the temperature inside the green-house was rather high (about 75°–80°F).

The spraying apparatus consisted of a spraying bottle mounted on a trolley which was pulled by an electric motor along rails. The solution was forced by compressed air (40 lb. pressure) up a spray arm fitted into the bottle and through a nozzle which gave a flat or "fan" spray, wide enough to cover the pots. The rate of travel of the trolley was so adjusted that it delivered the spray solution to the plants at the rate of 100 gallons per acre and in order to conserve spray solution an electrically operated tap was used to control the flow.

Observations.—To assess both the acute and the chronic toxicities due to the chemicals two seedling counts were made after spraying. The first count was made after 15 days and the second, after one month in the case of Japanese larch and after two months in the case of Scots pine.

In the case of Sitka spruce, figures obtained in the final count were rather irregular and unsatisfactory, as this species had suffered very considerably from the abnormally dry summer, and had thus to be discarded.

The following table gives the percentage kills affected by the various chemicals at the different concentrations :—

TABLE II

Treatment	% Kill				
	Scot spine		Sitka spruce	Japanese larch	
	After 15 days	After 2 months	After 15 days	After 15 days	After 1 month
Amm. sulphamate					
1%	0	0	0	3	64
2%	0	55	13	11	64
4%	0	83	52	31	87
Sod. thiocyanate					
1%	25	58	30	84	90
2%	30	21	40	100	100
4%	40	52	61	100	100
Pot. ethyl xanthate					
0·5%	13	25	10	14	39
1·0%	0	3	10	34	71
2·0%	8	32	11	59	75
Amm. D.N.B.P.					
0·1%	0	11	12	12	39
0·2%	13	32	60	70	84
0·4%	86	94	94	100	100
Sod. pentachlorophenate					
0·5%	55	67	17	100	100
1·0%	74	81	81	100	100
2·0%	100	100	100	100	100
Na.M.C.P.A.					
0·1%	0	3	59	22	65
0·2%	0	45	43	7	64
0·4%	19	84	75	73	94
Na.D.C.P.A.					
0·1%	23(4 in 17)	70	4	21	52
0·2%	0	10	11	11	63
0·4%	0	61	19	17	47

(*contd.*)

TABLE II—(*concld.*)

Treatment	% Kill				
	Scots pine		Sitka spruce	Japanese larch	
	After 15 days	After 2 months	After 15 days	After 15 days	After 1 month
Na.T.C.P.A.					
0·1%	17	25	26	5	35
0·2%	4	24	8	39	66
0·4%	0	37	21	10	82
OILS					
Esso vaporizing ..	0	26	27	83	87
Regent vaporizing ..	34	38	41	34	39
Shell T.P. 711 ..	19	19	55	36	53
A.I. white spirit W8/72 ..	26	28	30	22	31
Varsol ..	48	50	34	53	67
Diesel oil ..	49	61	45	96	100
EXTRACTS IN ODOURLESS KEROSENE					
Gasoline extract No. W8/395					
10%	23	23	24	22	29
17·5%	8	13	60	30	50
25%	1	8	31	10	26
Kerosene extract W8/409					
10%	23	26	31	22	32
17·5%	18	22	18	9	32
25%	7	16	15	12	19
Shell H–10					
10%	14	18	14	18	25
17·5%	47	50	9	15	37
25%	60	64	16	20	31
Lubricating oil extract W8/404					
10%	75	88	42	95	100
17·5%	68	85	79	100	100
25%	76	100	70	100	100
Odourless kerosene ..	0	0	13	29	53
Control ..	0	2·7	20	5	35

Analysis of the data.—The choice of a herbicide is governed by various factors such as the extent of damage to weeds and desirable plants, the types of weeds killed, the ease in handling and the economics of the technique employed. Considering the factor of damage to desirable plants, an ideal herbicide would be one which would kill all the weeds without in any way injuring the desired crop (in this case tree seedlings). Such a herbicide, however, appears to be a practical impossibility and, therefore, a certain allowance for the mortality of the seedlings themselves has to be made. Due to the interdependence of the various factors stated above, it is extremely difficult to define a particular limit to the mortality of the seedlings above which a chemical may be considered unsuitable. However, in view of the preliminary nature of these experiments, it is assumed that a loss of 20–30% in seedling stock does not seriously detract from the applicability of a particular herbicide to further investigations and such chemicals have, therefore, been considered worthy of further trials.

It may be observed that in some cases, e.g., potassium ethyl xanthate with Scots pine, the mortality figures are extremely irregular, in that, there appears to be no uniform increase in mortality with increasing dosage. Unfortunately, these experiments could not be adequately replicated so that anomalies of this kind can neither be confirmed nor discredited. In view of this, care must be taken in the assessment of the suitability of the particular herbicide involved.

1. *Amm. sulphamate.*—This was found most toxic to Sitka spruce and least toxic to Scots pine. Though immediate harm to seedlings was not great, considerable mortality occurred later on, which suggests that mortality occurs when the chemical is translocated down to roots. It does not appear suitable for use with any of these species.

2. *Sodium thiocyanate.*—This appears to be much more toxic to Japanese larch than to the other two species. However, mortality in the case of Scots pine and Japanese larch was too high to recommend its use with these species. In the absence of the record of a later count in the case of Sitka spruce, no definite recommendation can be made for this species but the high mortality in the case of the 4% solution suggests its unsuitability.

3. *Pot. ethyl xanthate.*—This also appears to be more toxic to Japanese larch. Considering that a 20% mortality was obtained in the controls for Sitka spruce after 15 days, this chemical appears to cause no damage to the seedlings. However, in the absence of adequate data no definite conclusions can be drawn, but it certainly deserves further trials with Sitka spruce and Scots pine.

4. *Amm. D.N.B.P.*—0·2% solutions show a high toxicity to Japanese larch and Sitka spruce but gave only about 30% mortality in the case of Scots pine. As this concentration has been found efficient in the control of many annual weeds there is some possibility for its use in Scots pine nurseries. Concentrations higher than 0·2%, however, appear to be extremely toxic to all the three species and thus may not be used in coniferous nurseries.

5. *Sodium penta-chlorophenate.*—This was found highly toxic to all the three species.

6. *Na.M.C.P.A.*—For efficient control of weeds a concentration of about 0·2% is generally used. Sitka spruce appears to be highly susceptible to this chemical and a high mortality occurred within 15 days of spraying. The effect on the other two species was slower in action but again appreciably high. However, in the case of Scots pine an 0·1% concentration did very little damage to the seedlings and, as this concentration of the chemical has been reported to kill many annual weeds in the very young stages, further investigations are suggested.

7. *Na.D.C.P.A.*—This appears to be less toxic to Sitka spruce than Na.M.C.P.A. The chemical appears to act slowly, as a fairly high mortality was indicated by the final counts of Scots pine and Japanese larch seedlings. Little harm, however, appears to have been done during the first fifteen days. Japanese larch appears to be relatively more resistant to Na.D.C.P.A. than to Na.M.C.P.A. (this has been observed also in other experiments carried out by the Agricultural Research Council and the Forestry Commission of England (cf. Appendix IV-B).

8. *Na.T.C.P.A.*—This was found more toxic to Japanese larch than the other two species. An 0·2% solution, which has been found effective on certain weeds, did only little damage to Scots pine and Sitka spruce seedlings and thus certainly deserves further trials, although it is known that at this concentration it is less effective against annual weeds than D.C.P.A. or M.C.P.A.

9. *Esso vaporizing oil.*—This showed a very high toxicity, both acute and chronic, to Japanese larch, whilst Scots pine and Sitka spruce were only slightly affected. This is in agreement with Eliason's (1949) observations in which he found that, while evergreen coniferous species were generally resistant to oil sprays, deciduous species like larch were often highly susceptible.

10. *Regent vaporizing oil.*—This did not show a very high mortality and there was little difference between the acute and chronic effects of toxicity. Scots pine appeared to be the most susceptible of the three species and a mortality of about 35% occurred but due to lack of adequate data no definite conclusions can be drawn and the chemical deserves further trials with all the three species.

11. *Shell T.P. 711.*—This appeared to be most toxic to Sitka spruce and least toxic to Scots pine but this was not confirmed by the seed bed experiments (cf. page 42).

12. *Anglo Iranian white spirit W8/72.*—This was found only slightly toxic to all seedlings and appears to be safe to use with these species. This fact has been confirmed by the seed bed experiments.

13. *Varsol.*—This showed a higher toxicity to Scots pine than to Sitka spruce or Japanese larch but this fact is not corraborated by the bed experiments as described later (cf. page 42).

14. *Diesel oil.*—This showed considerable toxicity to all the three species and hence cannot be recommended. It was highly toxic to Japanese larch giving a 100 per cent mortality.

15 and 16. *Extracts W8/395 and W8/409.*—Little difference between acute and chronic toxicities was shown. An interesting observation made with these extracts was that the toxicity decreased with increasing concentration. It is possible that, as these substances are of higher viscosity, the higher concentrations are less able to penetrate into the tissues of the plants than are the lower concentrations, hence giving a lower toxicity. None of these extracts appear to be highly toxic to these species and deserve further trials.

17. *Shell H-10.*—This was found fairly toxic to Scots pine, a 17·5% concentration giving a mortality in the range of 50% and a 25% solution a mortality of 60%. On Japanese larch and Sitka spruce, however, it appeared to have only negligible effects, a fact which is very interesting, particularly since it has been known to kill a wide variety of nursery weeds at 20–25% concentrations.

18. *Extract W8/404.*—This was found extremely toxic and thus appears to have little value as a selective herbicide for coniferous species.

19. *Odourless kerosene.*—It is generally understood that this chemical is not toxic to coniferous seedlings and can safely be used as a diluent. This appears to be confirmed for Scots pine and Sitka spruce but high figures of mortality have been obtained in the case of Japanese larch. The reason for this high mortality is not known but, in view of the fact that only 1 pot was sprayed and that the seedlings were probably suffering from drought, further experiments are necessary before these findings can definitely be established. It is of interest to note that in other experiments on Japanese larch, where kerosene has been used as a diluent, no such mortalities occurred.

II. SEED BED EXPERIMENTS

Treatment.—Three oils, Shell T.P.711, Anglo Iranian white spirit W8/72, and Varsol were tested on Scots pine, Sitka spruce and Japanese larch. The oils were applied pure at the rates of 40, 70 and 100 gallons per acre under a pressure of about 30 lb.

Technique.—The unit of treatment with each concentration was a plot $3' \times 2\frac{1}{2}'$. The plots were arranged along two beds of 100[1] length each at Kennington Nursery, Oxford, and were randomized for the different treatments. Two replicates were used. Sowing was done on March 18, 1949. Seeds were sown broadcast and were mixed with red lead before sowing, to facilitate even distribution as well as to give protection against rodents, etc. An intervening strip of 6″ between the plots was left unsown to minimize the effects of spray drift. The weather after sowing was hot and dry which delayed germination and necessitated occasional watering. Weeds came up much earlier than the seedlings and the beds had to be weeded by hand to help the growth of the seedlings.

Spraying was done when most of the seedlings were in the young true leaf stage but due to irregularity in germination many seedlings in the cotyledonary stage and some with the seed coat still on were also present. Scots pine germinated earliest of all and was sprayed after about 2 months. Japanese larch was sprayed about 9 weeks after sowing but the germination of Sitka spruce was very slow and irregular and it could not be sprayed until about 13 weeks after sowing. Spraying of Scots pine and Japanese larch was done on the 23rd and 26th of May respectively while the Sitka spruce was sprayed on June 27. The height of seedlings at the time of spraying was on the average 1″ to $1\frac{1}{2}$″. In the case of Sitka spruce a fair percentage (about 20%) of the seedlings were dying of drought at the time of spraying.

The weather at and immediately after the time of spraying of the Scots pine and Japanese larch was moderately cool and cloudy with occasional light drizzle and interrupted periods of hazy sunshine. At the time of spraying the Sitka spruce, however, the weather was bright and very hot with a slight breeze. Spraying in all cases was done in the afternoon between 3 and 4:30 p.m.

Spraying was done with a Martsmith hand-pump sprayer having a nozzle producing a fan shaped spray. To avoid spray drift from one plot to another, wooden boards about 8″ high were placed between the plots facing the direction of the wind and spraying was done as low as possible.

Observations.—It was intended to make two counts of the seedlings after spraying, one to assess acute toxicity, the other chronic toxicity. In the case of the Sitka spruce, however

only one count (after 7 weeks) was possible. Scots pine and Japanese larch seedlings were counted twice, 18 days and 11 weeks after spraying. The results are tabulated below :—

TABLE III

Treatment	% Kill				
	Scots pine		Sitka spruce	Japanese larch	
	After 18 days	After 11 weeks	After 7 weeks	After 18 days	After 11 weeks
Shell T.P. 711					
40 galls/acre ..	17	29	43	15	40
70 galls/acre ..	8	21	55	17	43
100 galls/acre ..	36	49	49	11	47
A.I. white spirit					
40 galls/acre ..	19	33	41	9	41
70 galls/acre ..	13	22	54	3	33
100 galls/acre ..	15	19	52	19	48
Varsol					
40 galls/acre ..	3	26	54	7	45
70 galls/acre ..	12	29	61	25	43
100 galls/acre ..	16	34	67	38	60
Control ..	6	21	42	7	39

Analysis of the data—

1. None of the oils appear to have a significantly toxic effect on these species when used up to 70 gallons per acre.
2. At 100 gallons per acre Varsol in the case of Japanese larch and Sitka spruce and Shell in the case of Scots pine give a mortality of about 25% to 30%, but this again is not considered unduly great.
3. It, therefore, appears that these oils can safely be used with these species, though in certain cases applications above 70 gallons an acre may prove slightly harmful.
4. Varsol appears to be slightly more toxic to Japanese larch and Sitka spruce than to Scots pine, but the results of the pot experiments give just the reverse indications. In the absence of further experimental work no conclusions can be drawn as to the reason for this contradiction.
5. The three white spirits used do not appear to differ widely in their toxicity to coniferous plants especially up to a rate of application of 70 gallons per acre.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*b*) (Analytical Method)—*continued*

(*Continued from the* Indian Forester, *February 1951, page 148*)

(K) Calculations of *Max. positive shears* in panels of Howe truss due to panel live loads :—

(1) To find max. positive live load shear in the first panel $L_0\ U_1\ L_1$: (Fig. 100).

(*a*) Load all panel points at L_1, L_2......to L_7 with panel live loads of 5600 lb. (at each panel point) [Refer page 141 para J(5)(*a*)].

(*b*) Find reaction R_1 which gives the value of max. positive shear in the 1st panel :

$\therefore$ Taking moments about point L_8 we get

$$R_1 \times (8\times5) = 5\cdot6 \times (7\times5) + 5\cdot6 \times (6\times5) + 5\cdot6 \times (5\times5) + 5\cdot6 \times (4\times5) + 5\cdot6 \times (3\times5) + 5\cdot6 \times (2\times5) + 5\cdot6 \times (1\times5).$$

Simplifying we get

$$\therefore\ R_1 = \tfrac{1}{8} \times 5\cdot6\ \{1 + 2 + 3 + 4 + 5 + 6 + 7\}.$$

By cancelling out 5 and dividing by 8

$$R_1 = \frac{1}{8} \times \frac{5\cdot6}{1} \times \frac{28}{1} = 19\cdot6 \text{ in thousands of lb.}$$

Thus max. positive shear due to live load in 1st panel is equal to $V_1 = 19\cdot6$ in thousands of lb.

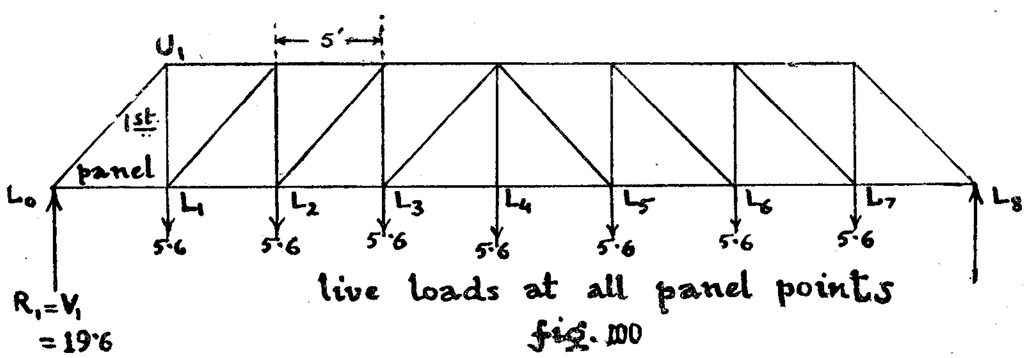


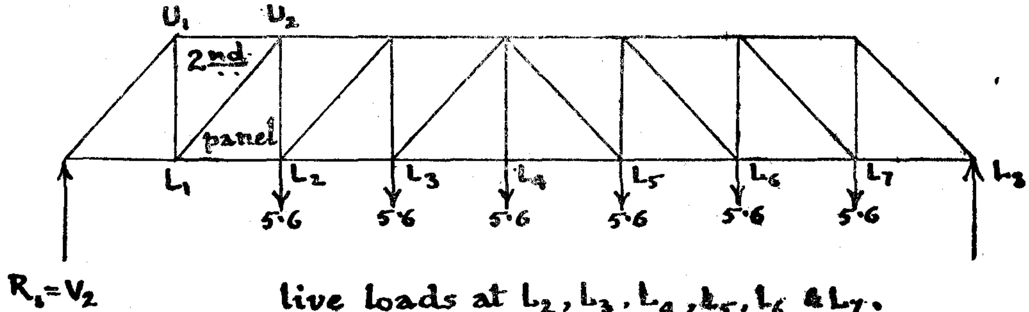
fig. 100

(2) To find max. positive shear due to live load in the 2nd panel $U_1\ L_1\ L_2\ U_2$: (Fig. 101)

$V_2 = \frac{1}{8} \times 5\cdot6\ \{1 + 2 + 3 + 4 + 5 + 6\}$ ....as per method on page 141 para J(5)(*a*)

$$= \frac{1}{8} \times \frac{5\cdot6}{1} \times \frac{21}{1}$$

$\therefore\ V_2 = 14\cdot7$ in thousands of lb.



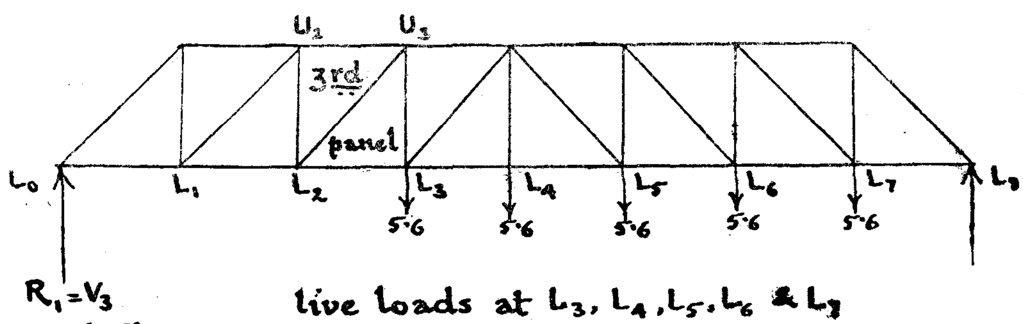
live loads at L_2, L_3, L_4, L_5, L_6 & L_7.
fig. 101

(3) To find max. positive shear due to live load in the 3rd panel $U_2 L_2 L_3 U_3$: (Fig. 102)

$$V_3 = \tfrac{1}{8} \times 5\cdot6 \{ 1 + 2 + 3 + 4 + 5 \}$$

$$= \frac{1}{8} \times \frac{5\cdot6}{1} \times \frac{15}{1}$$

$\therefore\ V_3 = 10\cdot5$ in thousands of lb.



live loads at L_3, L_4, L_5, L_6 & L_7
fig. 102

(4) To find max. positive shear due to live load in the 4th panel $U_3 L_3 L_4 U_4$: (Fig. 103)

$$V_4 = \frac{1}{8} \times \frac{5\cdot6}{1} \left\{ 1 + 2 + 3 + 4 \right\}$$

$$= \frac{1}{8} \times \frac{5\cdot6}{1} \times \frac{10}{1}$$

$\therefore\ V_4 = 7\cdot0$ in thousands of lb.

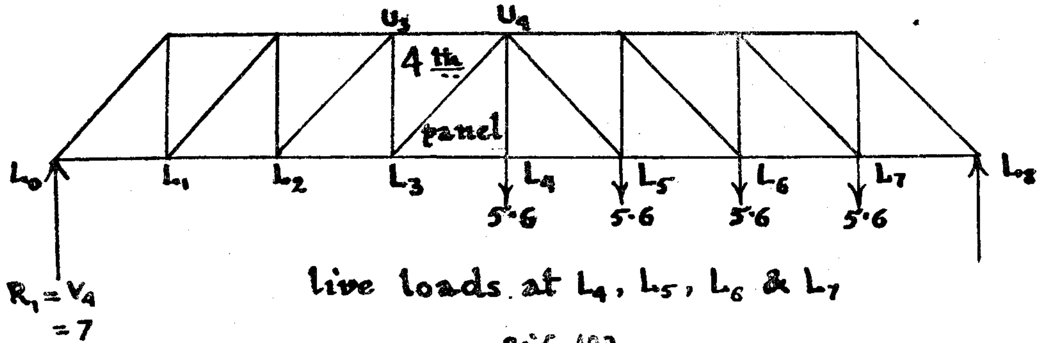


fig. 103

(5) To find max. positive shear due to live load in the 5th panel $U_4 L_4 L_5 U_5$: (Fig. 104)

$$V_5 = \frac{1}{8} \times \frac{5 \cdot 6}{1} \left\{ 1 + 2 + 3 \right\}$$

$$= \frac{1}{8} \times \frac{5 \cdot 6}{1} \times \frac{6}{1}$$

$\therefore$ $V_5 = 4 \cdot 2$ in thousands of lb.

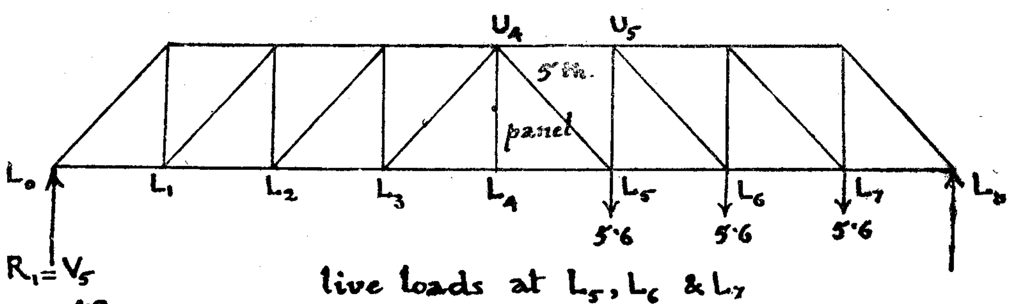


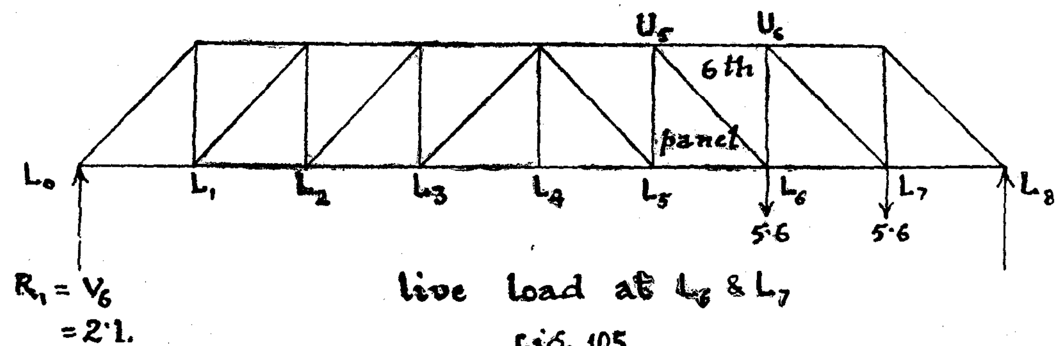
fig. 104

(6) To find max. positive shear due to live load in the 6th panel $U_5 L_5 L_6 U_6$: (Fig. 105)

$$V_6 = \frac{1}{8} \times \frac{5 \cdot 6}{1} \left\{ 1 + 2 \right\}$$

$$= \frac{1}{8} \times \frac{5 \cdot 6}{1} \times \frac{3}{1}$$

$\therefore$ $V_6 = 2 \cdot 1$ in thousands of lb.

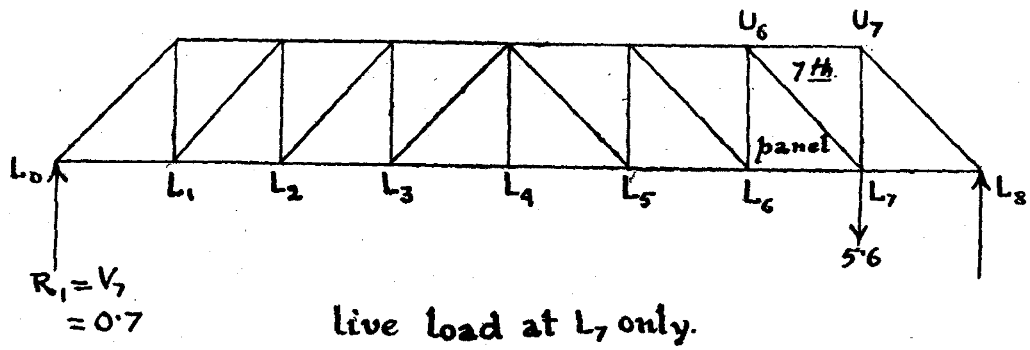


live load at L6 & L7

fig. 105

(7) To find max. positive shear due to live load in the 7th panel $U_6 L_6 L_7 U_7$:
(Fig. 106)

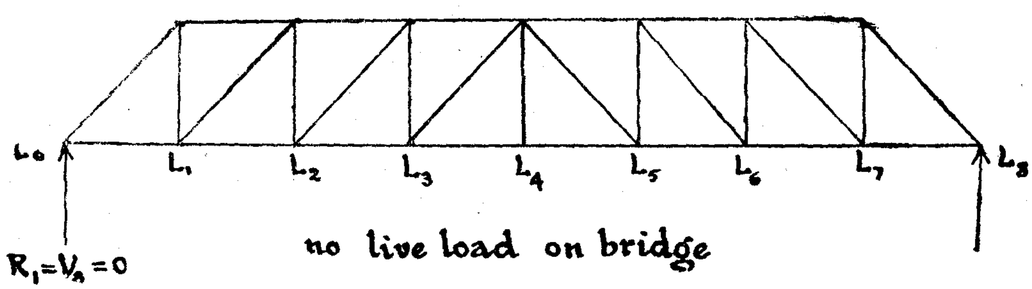
$$V_7 = \frac{1}{8} \times \frac{5 \cdot 6}{1} \left\{ 1 \right\}$$
$$= 0 \cdot 7 \text{ in thousands of lb.}$$



live load at L7 only.

fig. 106

(8) To find max. positive shear due to live load in the 8th panel $L_7 L_8 U_7$:
(Fig. 107)
$V_8 = R_1 =$ Zero (as there is no live load on the bridge to the right of point L_7).



no live load on bridge

fig. 107

(L) Calculations of max. negative shears in panels of Howe truss due to panel live loads :—

(1) *Introduction.*—In calculating max. negative shears, sometimes called the 'minimum shears' [according to page 142 para J(5) (*b*)], the reaction R_1 is not the same as the shear in the panel (as was the case for max. positive shears) because there are loads to the left of the section and these must be subtracted from the reaction [vide page 142 para J(5) (*b*)].

(2) Thus putting down conditions of live loadings for max. negative shears for the Howe truss under consideration and tabulating max. negative shears in different panels we have :—

Position of panel in which max. negative shear is desired	Positions of panel points loaded for the condition of max. negative shear in the panel. (Panel live load = 5600 lb.)	Calculations for max. negative shears in the particular panel (in thousands of lb.)	Value of max. negative shear (in thousands of lb.)	REMARKS
1st Panel ..	None of the points loaded	..	$V_1 = 0$	Fig. 108*a*
2nd Panel ..	Point L_1	$+R_1-L_1$ $= +4\cdot9-5\cdot6$	$V_2 = -\cdot7$	Fig. 108*b*
3rd Panel ..	Points L_1 & L_2	$+R_1-(L_1+L_2)$ $= +9\cdot1-(5\cdot6+5\cdot6)$	$V_3 = -2\cdot1$	Fig. 108*c*
4th Panel ..	Points L_1, L_2 & L_3	$R_1-(L_1+L_2+L_3)$ $= 12\cdot6-(3\times5\cdot6)$	$V_4 = -4\cdot2$	Fig. 108*d*
5th Panel ..	Points L_1, L_2, L_3 & L_4	$R_1-(L_1+L_2+L_3+L_4)$ $= 15\cdot4-(4\times5\cdot6)$	$V_5 = -7$	Fig. 108*e*
6th Panel ..	Points L_1, L_2, L_3, L_4 & L_5	$R_1-(L_1+L_2+L_3+L_4+L_5)$ $= 17\cdot5-(5\times5\cdot6)$	$V_6 = -10\cdot5$	Fig. 108*f*
7th Panel ..	Points L_1, L_2, L_3, L_4, L_5 & L_6	$R_1-(L_1+L_2+L_3+L_4+L_5+L_6)$ $= 18\cdot9-(6\times5\cdot6)$	$V_7 = -14\cdot7$	Fig. 108*g*
8th Panel ..	Points L_1, L_2, L_3, L_4, L_5, L_6 & L_7	$R_1-(L_1+L_2+L_3+L_4+L_5+L_6+L_7)$ $= 19\cdot6-(7\times5\cdot6)$	$V_8 = 19\cdot6$	Fig. 108*h*

Note.—From the above table we notice that max. negative shears are numerically equal in value to max. positive shears [vide page 192 para K (1) to (8)] but they occur in reverse order, i.e., max. +tive shear in 1st panel = max. —tive shear in 8th panel, etc.

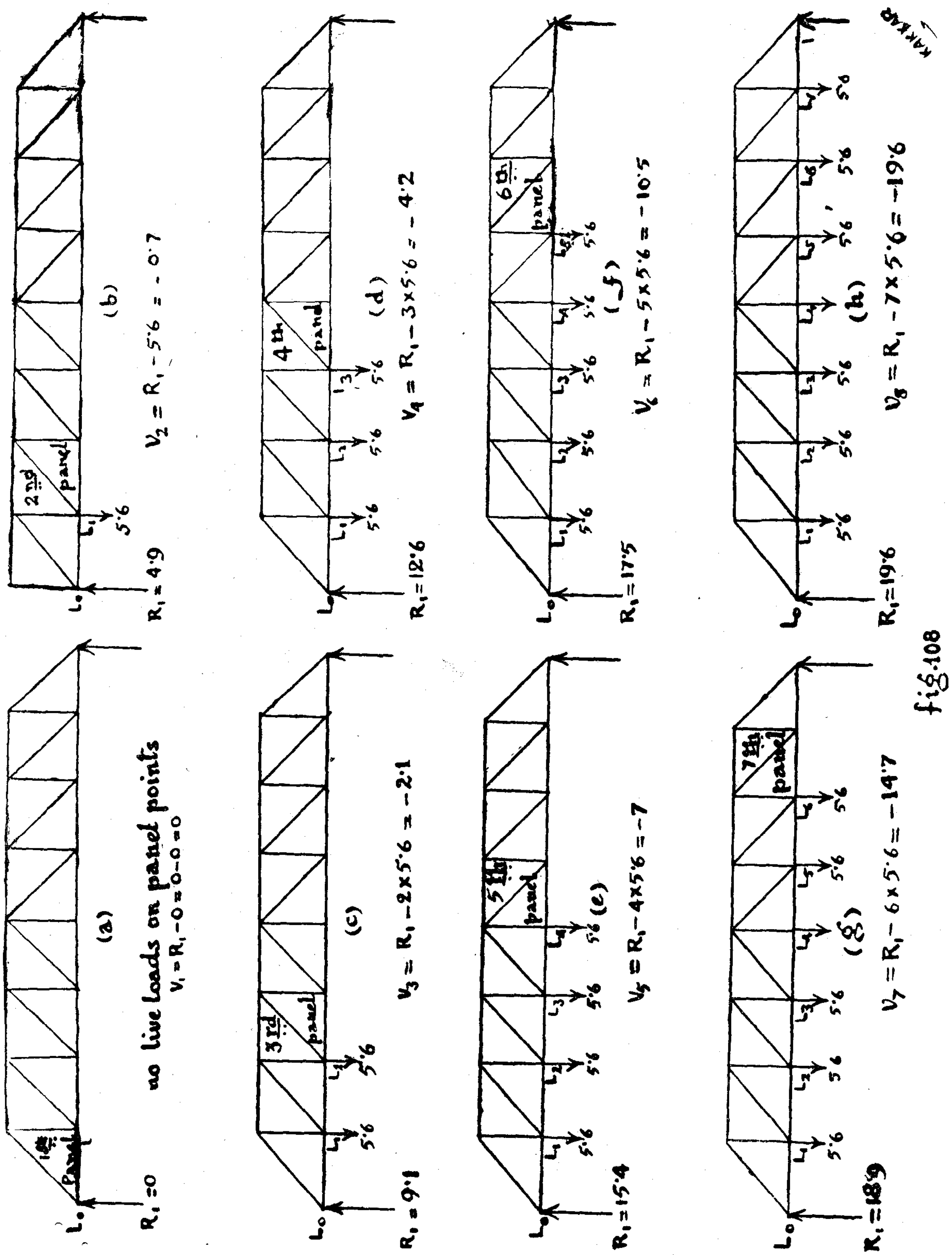

(a)
no live loads on panel points
$V_1 = R_1 - 0 = 0 - 0 = 0$
$R_1 = 0$
(b)
$V_2 = R_1 - 5{\cdot}6 = -0{\cdot}7$
$R_1 = 4{\cdot}9$
(c)
$V_3 = R_1 - 2 \times 5{\cdot}6 = -2{\cdot}1$
$R_1 = 9{\cdot}1$
(d)
$V_4 = R_1 - 3 \times 5{\cdot}6 = -4{\cdot}2$
$R_1 = 12{\cdot}6$
(e)
$V_5 = R_1 - 4 \times 5{\cdot}6 = -7$
$R_1 = 15{\cdot}4$
(f)
$V_6 = R_1 - 5 \times 5{\cdot}6 = -10{\cdot}5$
$R_1 = 17{\cdot}5$
(g)
$V_7 = R_1 - 6 \times 5{\cdot}6 = -14{\cdot}7$
$R_1 = 18{\cdot}9$
(h)
$V_8 = R_1 - 7 \times 5{\cdot}6 = -19{\cdot}6$
$R_1 = 19{\cdot}6$
KAKKAR

fig. 108

(M) Consideration of counter-braces in Howe truss :—

(1) Putting max. shears due to (*a*) Panel dead loads
and (*b*) Panel live loads
(i) max. positive shear
(ii) max. negative shear

in tabular form we have :

Name of Panel	Max. dead load shear	Max. positive live load shear	Max. negative live load shear
	Condition : Refer page 132 para C(2) and Fig. 87	Condition : All loadings always to Right of the section [Refer para K(1) to (8) page 192]	Condition : All loadings always to Left of section [Refer para L(2) page 196]
	In 1000 lb.	In 1000 lb.	In 1000 lb.
1st Panel ..	+9·25	+19·6	0
2nd Panel ..	+6·60	+14·7	− ·7
3rd Panel ..	+3·95	+10·5	− 2·1
4th Panel ..	(+1·30)	+ 7·0	(− 4·2)
5th Panel ..	(−1·30)	(+ 4·2)	− 7·0
6th Panel ..	−3·95	+ 2·1	−10·5
7th Panel ..	−6·60	+ ·7	−14·7
8th Panel ..	−9·25	+ 0	−19·6

(2) Condition under which a counter-brace is required :—

Rule (7).—If live load shear (considering either max. +tive or max. negative i.e., any one of the two) in any panel is

(*a*) of opposite sign and at the same time

(*b*) numerically greater than max. dead load shear in the same panel, than a counter is required in that panel.

(3) *Example*.—From the inspection of the above table on M(1), we find that counters are required in (i) 4th and (ii) 5th panels because

(i) In 4th panel, max. shear due to live load of (−4·2) is
(*a*) of opposite sign to that of max. dead load shear of (+1·30)........... see para M(1) above

and at the same time

(*b*) Max. shear due to live load of (−4·2) is numerically greater than that of max. dead load shear of (+1·30).

(ii) In the 5th panel, max. shear due to live load of (+4·2) is

(*a*) of opposite sign to that of max. dead load shear of (−1·30) para M(1) above

and at the same time

(*b*) max. shear due to live load of (+4·2) is numerically greater than that of max. dead load shear of (−1·30).

(4) Counter-braces are also necessary to reduce the vibrations that are caused otherwise, even if the diagonal is designed for the duel purpose of taking, (i.e., sustaining) both compression and tension, as they come on the diagonal due to certain positions of live loads on the bridge.

(N) Determination of stresses in the diagonals of the Howe truss due to panel live load :—

(1) The same rule as on page 136 para F(4) applies, viz.

Stress in a diagonal due to panel live loads $= V_1 \times \sec \phi$

where $V_1 =$ 'shear due to panel live load' at the section cutting the diagonal
$\phi =$ angle the diagonal makes with the vertical.

(2) In the diagonals, the nature of stress is assumed to be 'compressive'—[this will be proved in Part V(*c*)].

(3) Again we had deduced from page 135 para F(1), F(2) and F(3) that

(i) Positive shears due to live load will produce compressive stresses in the diagonal of the left-half of the truss

and (ii) Negative shears due to live load will produce compressive stresses in the diagonals of the right-half of the truss.

(4) From para N(1) to N(3) above we can tabulate :—

Stresses in Diagonals due to live load :—

↓ 1	Diagonals in left-half of truss } are	$L_0 U_1$ ↓	$L_1 U_2$ ↓	$L_2 U_3$ ↓	$L_3 U_4$ ↓
2	Positive shears due to panel live loads } are	19·6	14·7	10·5	7·0
3	Secant $\phi = \sec 45°$	1·415	1·415	1·415	1·415
4	Value of stress in the diagonals $V_p \times \sec \phi$	19·6×1·415 = −27·73	14·7×1·415 = −20·80	10·5×1·415 = −14·85	7·0×1·415 = − 9·90
5	General Remarks. See Fig. 109	(1) Negative sign is affixed to stresses of the diagonals because diagonals are in compression. (2) Shear at the section due to live load = shear in the panel due to live load, i.e., $V_s = V_p$ because there are no negative downward loads at points U_1 U_2, etc., as was the case in considering shear at the section due to dead loads.			
4	Value of stress in the diagonals $V_p \times \sec \phi$	7·0×1·415 = −9·90	10·5×1·415 = −14·85	14·7×1·415 = −20·80	19·6×1·415 = −27·73
3	Secant $\phi = \sec 45°$	1·415	1·415	1·415	1·415
2	Negative shears due to panel live loads } are	7·0	10·5	14·7	19·6
1 ↑	Diagonals in right half of truss } are	L_5 ↑ U_4	L_6 ↑ U_5	L_7 ↑ U_6	L_8 ↑ U_7

Note.—The above calculations for finding stresses in diagonals due to live loads are done the same way as for the calculations for finding stresses in diagonals due to dead loads, the only diff. is that panel live loads acts through the nodes of the bottom boom whereas in the panel dead loads, $\frac{1}{3}$ of the dead load was presumed to be acting on the nodes of the top boom and only $\frac{2}{3}$ of the dead loads acting through the nodes of the bottom boom [Refer para H *Rule* (*3b*) page 39, Part V(*a*)].

(P) Determination of stresses in the verticals of the Howe truss due to panel live loads :—

(1) The same Rule 4 as on page 136 para G(1) applies, viz.

$S_v = V_s$ where

S_v = stress in the vertical due to live load.

V_s = shear due to live load at the section cutting the vertical.

= shear due to live load in the panel, i.e., V_p

$\therefore\ S_v = V_s = V_p$.

(2) In the verticals, the nature of stresses is assumed to be 'tensile'—[this will be proved in Part V(c)] and, therefore, value of the stress in any vertical will bear a positive sign (+) as per our assumptions in Fig. 109.

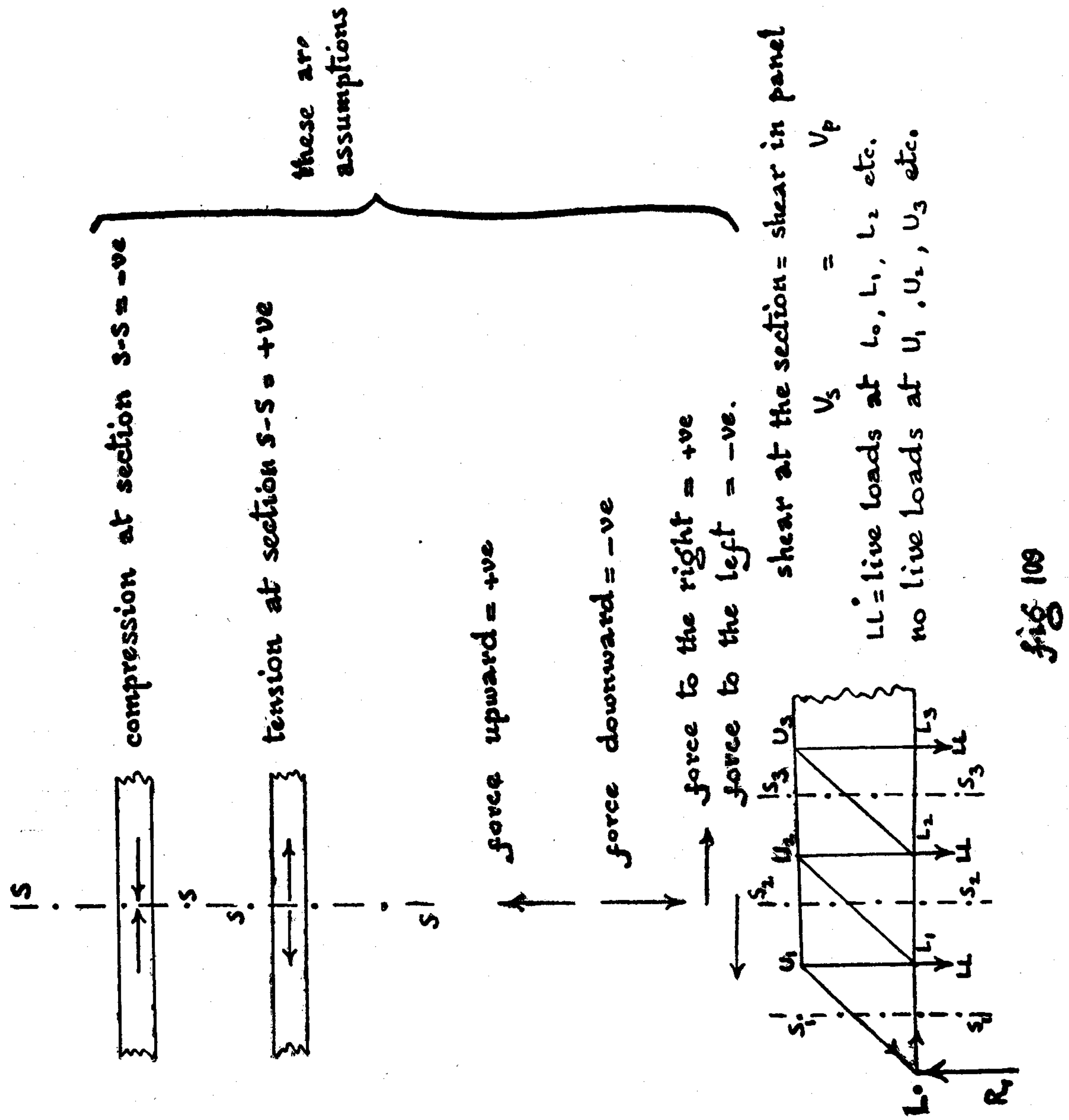


fig 109

(3) From paras P(1) and P(2) above, and referring paras K(1) to K(8) for values of V_p (i.e., shear in panel due to live loads) we can tabulate :—

Stresses in verticals due to live loads :—

Vertical member	Stress in the member (= shear in that panel) In thousands of lb.	REMARKS
$U_1 L_1$	$+19\cdot6$	(*a*) When live load moves from Right to Left. ← (*b*) Positive sign is affixed to the numerical values of stresses because we have assumed the vertical members to take tensive forces.
$U_2 L_2$	$+14\cdot7$	
$U_3 L_3$	$+10\cdot5$	
$U_4 L_4$	$+\ 7\cdot0$	
$U_5 L_5$	$+10\cdot5$	(*a*) When live load moves from Left to Right. → (*b*) Positive sign is affixed to the numerical values of stresses because by assumption, verticals take tension.
$U_6 L_6$	$+14\cdot7$	
$U_7 L_7$	$+19\cdot6$	

Note.—At any time, traffic on the bridge is one way (i.e., when a load moves on the bridge from Right to Left, there will be no other load moving simultaneously from Left to Right, and vice versa).

(Q) (1) When the bridge is under the action of a live load (i.e., when a live load passes over a bridge), to prove analytically that

"for certain positions of this live load on the bridge, a reduction in the 'dead load stress of the vertical $U_4 L_4$' actually occurs".

Note.—[The above statement was clearly seen in the Fig. 78, State III, Part V(*a*) of the graphical method].

(2) To prove analytically the above statement we have to consider the bridge under the action of both

(*a*) The dead loads

and (*b*) The live loads.

(3) Referring Fig. 110 and

(*a*) considering panel point L_4 and others to the right of it to be loaded with panel live loads along with $\frac{2}{3}$rd of panel dead loads (i.e., $1\cdot76$)

at the same time

(*b*) considering remaining panel points at bottom joints and to the left of L_4 to be loaded only with $\frac{2}{3}$rd of panel dead load (i.e., no live loads on these points)

and also (*c*) all panel node points at top (viz., $U_1 U_2$, etc.) loaded with $\frac{1}{3}$ of panel dead loads (i.e., $0\cdot88$)

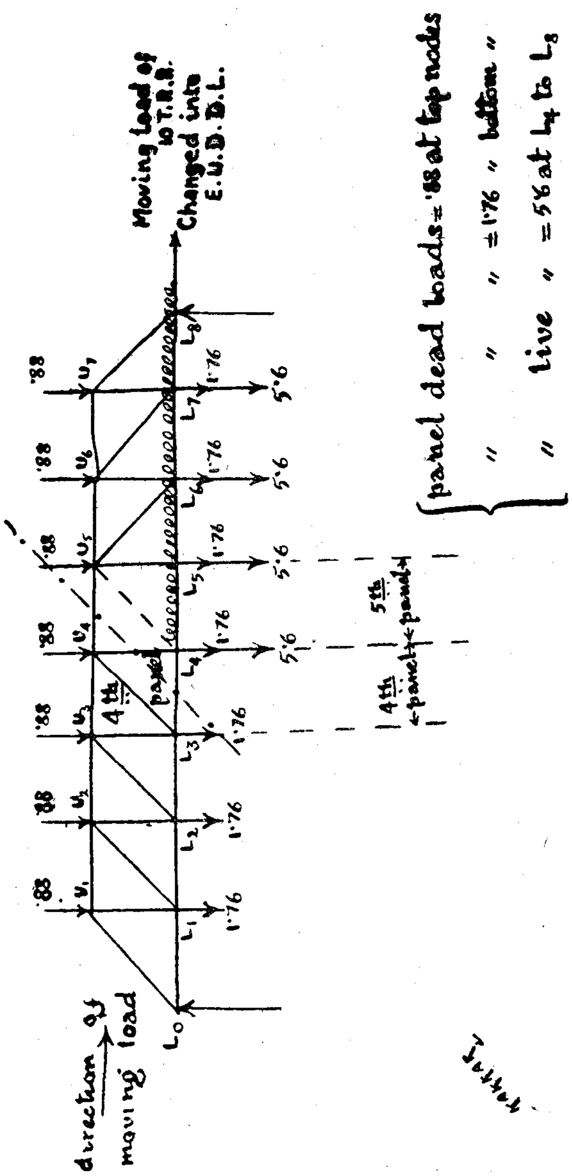
(*d*) considering section 4 — 4 such that it cuts the member $U_4 L_4$

[whose stress is to be found out under conditions of both, live and dead loads as mentioned in para (3)(*a*) and (*b*) above] and as few other members as possible.

(4) We deduce that (Fig. 110)

(*a*) a counter-brace $L_4 U_5$ is required in the 5th panel instead of a diagonal $U_4 L_5$ as was the case when only dead loads were considered on the bridge [Refer page 138 para G(2) (*d*) and Fig. 96].

Note.—[The above inference is established with conditions (*a*), (*b*) and (*c*) of para Q(3) above].



	4th panel	5th panel	reference para
Dead load shear	+1·30	−1·30	M(1) page table
live load shear	+7·00	+4·2	" " "
resultant shear	+8·30	+2·90	

Note— condition of putting a counterbrace L_4U_5 can easily be noticed from the results of shears in the 5th panel (ref. rule in para M(2) page)

fig. 110

(*b*) Now taking into account the above inference in para (4)(*a*), i.e., a counter-brace is acting and not the diagonal $U_4 L_5$ and considering section (4) — (4) as in para Q(3)(*d*) on page 201,

the dead load shear on section (4) — (4) is (Fig. 111) (considering force upwards +tive and force downwards —tive)

$$\text{we have } R_1 - \underbrace{(0{\cdot}88+1{\cdot}76)-(0{\cdot}88+1{\cdot}76)-(0{\cdot}88+1{\cdot}76)} \;-\; \underbrace{0{\cdot}88} \qquad (\text{Fig. } 111)$$

$$\text{i.e.} \quad \underbrace{9{\cdot}25 - (32{\cdot}64)} \;-\; \underbrace{0{\cdot}88}$$

$$\text{i.e.} \quad \underbrace{\left(\begin{matrix}\text{shear due to dead load}\\ \text{in 4th panel}\end{matrix}\right)} \;-\; \underbrace{\left(\begin{matrix}\text{Dead load}\\ \text{at } U_4\end{matrix}\right)}$$

$$\text{i.e.} \quad +1{\cdot}30 \;-\; 0{\cdot}88 \;=\; 0{\cdot}45$$

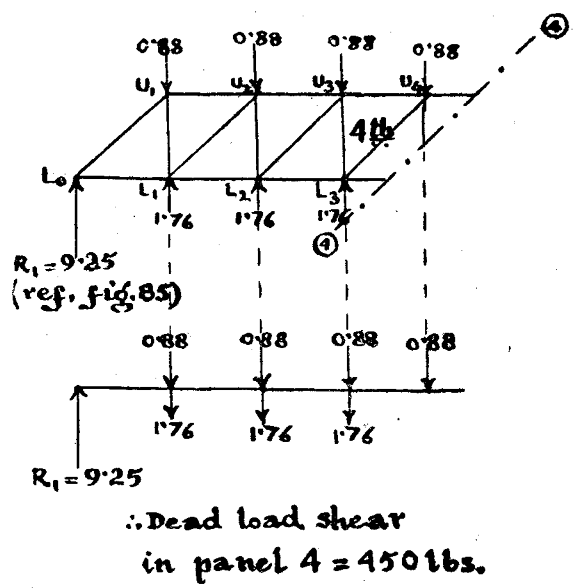


fig. 111

(5) Therefore

(*a*) shear on section (4) — (4) due to dead load when live load on bridge exist as per conditions in para Q(3)(*a*), (*b*) and (*c*), page 201 is + 0·45 in thousands of lb.

(*b*) Now we know that stress in the vertical equals the shear at the section which cuts the vertical member.

(6) Therefore

(*a*) Stress in vertical $U_4 L_4$ due to para Q(5) (*b*) is $+1{\cdot}76$ in thousands of lb. and positive sign shows that it is in tension [Refer para G(2) (*d*)(iii) page 139].

(*b*) Stress in vertical $U_4 L_4$ due to para Q(5)(*a*) is $+0 \cdot 45$ in thousands of lb. and is in tension.

(*c*) From para (6)(*a*) and (*b*) above we see that

$\cdot 45 < 1 \cdot 76$

i.e., 450 lb. $<$ 1760 lb.

(7) Inference

i.e. (*a*) for certain positions of the live load on bridge, a reduction of the 'stress due to dead load' in the vertical member $U_4 L_4$ actually occurs, i.e., with live loadings from point L_4 to L_8, the dead load stress in $U_4 L_4$ falls from $+1760$ to $+450$.

(*b*) and 'the certain positions of the live load' when such reduction occurs is when

all panel points to the right of point L_4 is loaded with panel live loads (of $5 \cdot 6$ in thousands of lb.).

(*c*) The reduction (in our case) of the 'stress due to dead load' is from 1760 lb. to 450 lb. in vertical member $U_4 L_4$.

Thus member $U_4 L_4$ is under less tension when live loads are placed from point L_4 to L_8 along with the dead loads, than when no live load exists on the bridge excepting the dead loads.

Note.—[The above inference in para Q(7) is of no direct influence on the design of member $U_4 L_4$ but is only of academical interest to note and understand the influence of moving loads].

(R) Determination of maximum stress in a counter-brace :—

(1) *Rule* (*8*).—The maximum stress in a counter-brace is given by the product of algebric sum of dead load shear and the live load shear in the panel requiring the counter-brace, and the secant of the angle which the counter-brace makes with the vertical.

Note.—[This above rule can be proved in the same manner as the proof of finding the stress in a diagonal (Refer Appendix V)].

(2) ∴ Max. stress in a counter-brace is given by the equation.

$S_m = V_s \sec \phi$

where S_m = Max. stress in a counter-brace.

V_s = Algebric sum of the dead load shear and the live load shear in the panel.

ϕ = the angle, counter-brace makes with the vertical.

(3) Taking an example in case of our bridge, find the max. stress in the counter-brace when live load is moving from Right to Left.

Solution :

(*a*) When live load moves from Right to Left, live loadings considered to the left of the section.

(*b*) Referring table (M) 1 on page 198 we find that there occurs on the bridge

(i) max. negative shears due to live loadings under conditions mentioned above in para R(3)(*a*).

(*c*) Now looking to the condition under which a counter-brace is required by the rule 7 on page 198 para M(2) we find that

(*d*) (i) 4th panel requires a counter-brace when live load moves from Right to Left, and

(ii) the max. dead load shear in the 4th panel (i.e., panel requiring the counter-brace) is $+1\cdot30$ and max. negative live load shear is $-4\cdot2$ [Refer page 198 para M(1) table].

(*e*) $\therefore$ V_s in our case of counter-brace.

= Algebric sum of the dead load shear and the negative live load shear in the 4th panel.

$\therefore$ $V_s = \{ (+1\cdot30) + (-4\cdot2) \} = -2\cdot90$ in thousands of lb.

(*f*) $\therefore$ Max. stress in counter-brace $V_s \times \sec \phi$

$$\therefore S_m = -2\cdot90 \times \sec 45^\circ$$
$$= -2\cdot9 \times 1\cdot415 \text{ in thousands of lb.}$$
$$= 4\cdot10 \textit{ in thousands of lb.}$$

$\therefore$ Max. stress in the counter-brace of 4th panel = 4100 lb.

(4) Similarly it could be proved that

(*a*) 5th panel requires a counter-brace when live load moves from Left to Right and

(*b*) the max. stress in the counter-brace is the same as that found in para R(3)(*f*).

Note.—[Para 4(*a*) above is clearly proved from Fig. 110 and para Q(4) page 202].

(To be continued)

FOREST RESEARCH INSTITUTE EXHIBITS AT THE INDIAN INTERNATIONAL ENGINEERING EXHIBITION AT DELHI

BY M. S. RAGHAVAN AND CAPTAIN N. J. MASANI

In March 1950, under the instructions of Shri C. R. Ranganathan, President of the Forest Research Institute given to the various branches in the Institute to arrange for suitable exhibits for the Indian International Engineering Exhibition, various exhibits prepared by the several branches were sent to the exhibition which is at the time of writing running in Delhi. (The Indian International Engineering Exhibition).

The Composite Wood branch exhibited several items including the following :—
- Construction of hollow bamboo stringer boards in stages,
- Laminated poles for service such as Electric poles, Telegraphic poles, etc.,
- Laminated Rifle furniture,
- Compregnated wooden bearings for textile machinery,
- Compregnated gear wheels,
- Compregnated bearing plates for sleepers, etc.

The Wood Preservation branch exhibited among others,
- Models showing preservation of wood by the Ascu method,
- The use of Ascu treated bamboos in roof covering.

The Wood seasoning branch, included in their exhibits,
- Pencil making by stages from Deodar, as a cottage industry,
- Battery separators from Indian timbers,
- Model of steam heated timber seasoning kiln,
- Assembly showing process of bending of wood for furniture and other purposes,
- Natural methods of seasoning timber.

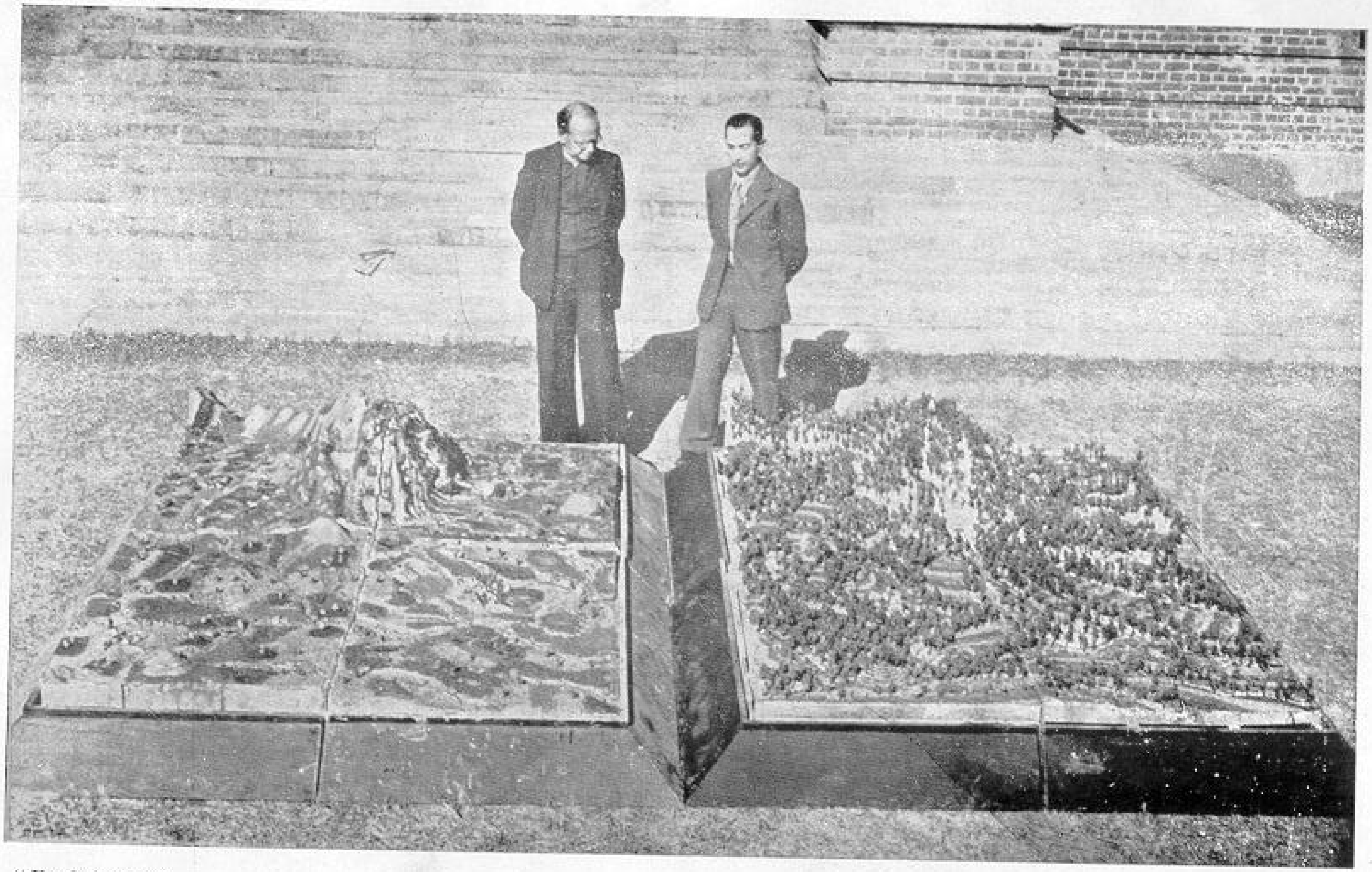
The Wood working branch exhibited some fine pieces, which included,
- Plywood cabin trunks,
- Plywood moulded chairs,
- Laminated veneered centre table,
- Wooden pulley blocks,
- Toys from wood waste.

The Timber testing branch, exhibited some highly instructive boards on the suitability of Indian timbers for various purposes, the suitability of Indian timbers specially for tool handles, and also
- Disc dowel joints in construction of roof trusses, etc.

The Mycology branch included some specimens of rot in structural timbers and furniture used in the armed services, navigation, aviation, etc. These specimens formed the basis for the arrangement of the exhibition.

The Silviculturist (Mr. M. S. Raghavan) and the Forest Engineering Lecturer (Capt. N. J. Masani) decided that in view of the present serious food situation in the country, the model of greatest topical importance would be one relating to soil erosion, including Engineering and Silvicultural methods of protection. These models had, therefore, to show the effects of proper land use in contrast with misuse. So a model was designed to contrast Eroded Land with a Land of Plenty. (Photo 1 opposite).

The construction of the model took ten months, and in this work we had the full participation of the ladies in the estate, and officers, staff and students of the Indian Forest College, who voluntarily gave great help out of Office hours, and on holidays.



"Eroded Land". PHOTO 1 "Land of Plenty".

PLATE 1

PLATE 2

PLATE 3

PLATE 4

After visiting the Survey of India map office, and examining a few maps, a topography which gave a wide range of conditions was selected. This topography included varying gradients from very steep ground to level, with a sufficiency of streams and a good site for constructing a hydro-electric dam and power house.

As the map was on a small scale of four inches to the mile and the model to be effective was to be on a large scale, a bromide enlargement by photography was made for us by the Map Office of the Survey of India. It was first intended that three enlargements were to be made, and then cut and pasted on plywood for constructing three models, two for showing land use and misuse, and one for instruction in road alignment on hills and plains and methods of timber extraction in the forest. But as the Bromide enlargements turned out to be costly, only one enlargement was made and the contour lines were traced on tracing paper by the Officer Students of the Indian Forest College with the kind permission of Shri V. P. Mathur, the Principal of the College, during their leisure hours.

The tracing which was eight feet long by six feet wide, to a scale of 24 inches to the mile (R.F. 1 : 2640), was cut into one foot squares, and mounted on three plywood in one foot square sections kindly supplied by the Wood Workshop. To economize time, these sections were nailed over three other equal pieces of plywood, so that four models can be cut simultaneously. The cutting consisted of sawing with the fret saw along the contour lines at 50 ft. intervals. When one contour line is 50 ft. above the next lower contour line, the vertical interval on the same scale will be only very small, therefore, the vertical scale was shown exaggerated to a scale of 1″ = 100 ft. (R.F. 1 : 1200).

In cutting these four models simultaneously on a Hobbies Treadle fret machine, it was found that work was too slow, and strenuous, and forcing the pace resulted in breakage of saws. Hence we removed the treadle, and the big drive wheel, and redesigned the machine to run from a quarter Horse Power 220 Volt. A.C. Electro motor, giving about 600 to 1,000 strokes per minute, switch operated by a switch working like the accelerator pedal of a Motor Car (Plate 1). The Service branch constructed these under our instructions, and our thanks are due to Messrs. Simon, Limaye, Saxena, Sitaram and T. R. Rao, for their great willing constant help.

As four models were made simultaneously, it was decided to use two models for soil conservation, and two for Forest Engineering instructions on road alignment and timber extraction.

When one set of twelve grids—a grid being a square foot—for a quarter of the model was cut, the profile for the four sides of each such grid was determined geometrically, and drawn on plywood, and as two neighbouring grids have the same profile on the common boundary, eight pieces were cut for each, in two or three stages.

The four profiles bounding grid were then assembled by half-inch wire nails, and wire ties, to simulate the sides of a box, and the inter contour steps were then nailed in position on the steps, to form the foundation of the topography (Plate 2). The application of a plastic substances in a uniform slope from the outer edge of one contour to the outer edge of the next contour above or below, resulted in the correct copying of the salients and re-entrants on the land, so that the correct topography is copied.

Due to the kind help of Drs. Bhat and Guha, Sardar Manmohon Singh, and other members of the paper pulp branch of the Forest Research Institute, we obtained sufficient quantities of papier mache which with some experiment was modified to suit our purposes, and this was applied by us in two stages on the model. The openings behind the steps were

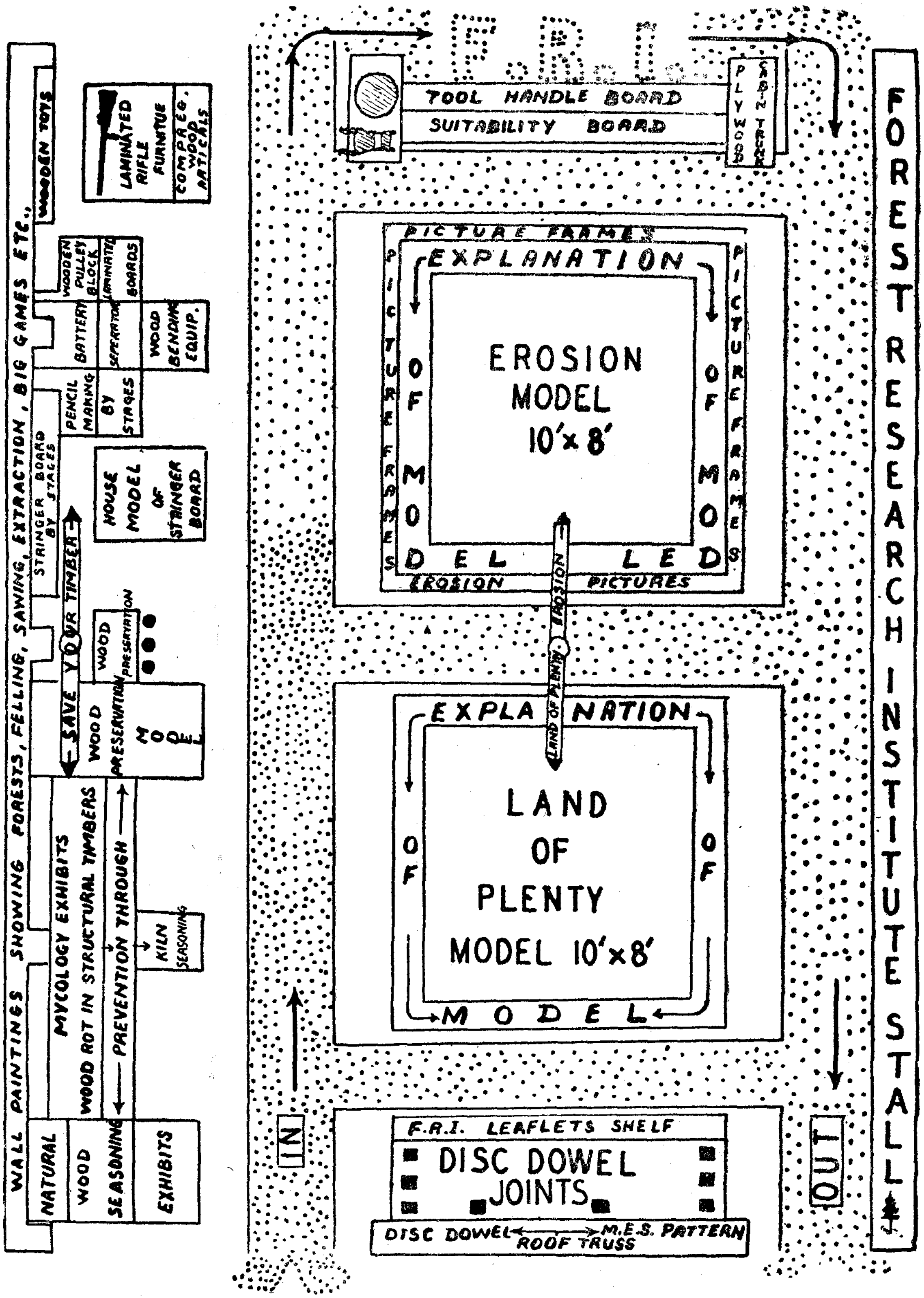
blocked up with papier mache at the first stage and this was allowed to dry before applying the papier mache on the face (Plate 4). Sometimes the contraction of the papier mache caused cracks, and these were filled up with more papier mache. Finally the surface was rendered with China clay.

In the earlier stages due to monsoon rains, we suffered from fungi which attacked the papier mache and also the foundation of plywood. On the advice of Dr. Narayanamurthi, a preservative (Santobrite) was brushed on the models, where the fungus had already appeared. But for the later stages of model construction a mild preservative was actually added to the papier mache and was successful as a preservative. In the construction of these models, including the very heavy work involved in cutting and assembling, the lion's share of the work was done by Messrs. J. George and R. S. Ratra of the Composite Wood branch, and our special gratitude is due to them for their regular, careful, continuous voluntry work, involving long hours after their long and arduous days in their own offices. Our thanks are also due to Sardar Gurdial Singh Mathauda, Shri Ghansyam, and the Students of the Officers class of the Indian Forest College for work in various aspects of this construction. Twelve neighbouring one foot square models were assembled by bolts and nuts to form one quarter of the entire block (Plate 3) and four such quarters blocks by juxta position on a suitable frame stand, gave one complete foundation model. The area covered was $8' \times 6'$ which is equivalent to twelve square miles for the complete model.

One such completed model constituted the "Erosion" model (Photo 1) showing different kinds of erosion such as sheet, gully, inversion with deposition at top of agricultural land of sterile soil, exposure of sheet rock, dislodgement and rolling of boulders destroying villages, farms, houses, people and cattle, deterioration of agriculture, disappearance of forests, siltation of streams, rivers and reservoirs, deflection of floods in new directions, resulting in further destruction of land, cultivation, habitation animals, and comminucation, all as a result of irrational cultivation, burning of grassland and forests, uncontrolled pasture, and wasteful methods of forest exploitation. Such misuse leads to submarginal cultivation further destruction, and final disappearance of civilizations.

Per contra, the second model was constructed to show how this area could be reconverted, or saved, so as to be a "Land of Plenty" (Photo 1) through Forestry, Engineering, and rational Agronomy, whereby soil conservation methods such as reservation of steep ground for growing trees and grass only, exclusion of grazing from such areas but allowing grass cutting, banishment of fires, protection of banks of water courses by belts of trees and strips of grass on both sides thus protecting the banks against the erosive effects of agricultural clean tillage, river training methods, terracing with or without basins, contour bunding, contour trenching, strip cropping rotational cropping (including stubble fallowing) contour ploughing, provision of paved or turfed waterways and water spreads even for irrigation channels (where they discharge into main water courses), provision of wind belts, proper engineering of roads, bridges, power houses, dam sites, and other constructions (as it is found that sometimes under inexpert constructions erosion starts at the discharge end of culverts, and on the unprotected ends of water courses above well cushions) and adopting such other methods as are necessary to create a proper balance of nature between man, his animals and their environments. While such models as ours are educative, legislation and co-operation are essential for the success of such operations.

The models thus indicate side by side that unscientific agriculture without soil conservation methods leads ultimately to the suffering, starvation, and death of man and beast, while scientific agriculture using soil conservation methods, results in improved fertility, and in a perennial balanced supply of man's needs, and thus the recreation of a "Land of Plenty" like what our ancestors are reported to have enjoyed.



Lay-out of the forest stall.

PLATE 5

In the finishing of the models, trees, grasses, and different kinds of cultivation had to be shown. For this purpose we have used green paint to represent grassland, green fairy work and yellow and red coloured saw dust representing different crops such as those used in strip cropping, and trees made from coloured luffa have given a realistic effect for trees. While the fairy work was kindly supplied to us by the ladies resident at the Forest Research Institute and Shri Surajuddin (who made a large quantity of this), the trees were made by Shri Vidya Dutt the Silvicultural Museum artist, and Shri Raj Kumar and Vidya Dutt gave great help in the finishing of the model. To all of these our thanks are due.

In the actual exhibition several captions were needed to make the model self-explanatory, and these captions designed by Captain Masani as advised by Shri C. R. Ranganathan the President of the Institute, were printed for us by the Printing Office, and our thanks are due to Shri Chandra Kishore, Shri N. L. Pali, Shri Shyam Singh and Shri C. L. Bhargava. The photographs which clearly show some of the interesting stages of the work were taken by Shri V. K. Sharma, Head Photographer of the photographic section of the Silviculturist's branch.

Shri K. L. Aggarwal, the Publicity and Liaisons Officer and Director of Forest Education, has kindly sponsored and helped the scheme in several stages, and permitted Captain N. J. Masani to attend to all the various stages of the construction and exhibition at Delhi. We feel deeply obliged to him for his great help.

Finally though we have been instrumental in conceiving and finalizing the idea, it is the officers and staff, and ladies of the Forest Research Institute who have all contributed to the work at various stages and to them all we finally tender our thanks, through Shri C. R. Ranganathan the President, who was the guiding force behind us throughout the period of construction and exhibition of the models at Delhi. (Plate 5 opposite).

M. S. RAGHAVAN,
CAPT. N. J. MASANI.

THE ROLE OF VEGETAL SOIL COVER IN FLOOD CONTROL

BY M. D. CHATURVEDI, I.F.S.
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SUMMARY

The severity of floods in the Indo-Gangetic basin is occasioned by the striking periodicity in monsoon and its intensity in the elevated Himalayan zone. Such powerful physical forces are best counteracted not by the rigid brick and mortar but by the resilient vegetation, the luxuriant growth of which in the region most affected is no fortuitous coincidence. The vegetal cover is Nature's device to control the forces it unleashes. In the proper management of the catchment areas of large rivers lies our best security against floods. The challenge of the millions of drops of rain can be met only by myriads of leaves.

The severity of floods in India is occasioned by the peculiar periodicity exhibited by the rainfall of this region. The vast bulk of the rain falls during the four monsoon months, viz., June to September. The remaining eight months of the year are practically dry with the exception of a few showers during the winter months. The total amount of rain incident on the land is not only ill-distributed in respect of *time*, but also in respect of *space*. Thus, the Himalayas by virtue of their height act as an impassable barrier to the rain-bearing clouds which precipitate with undue severity in this region. Both vegetation and rainfall practically disappear in the high mountains above the elevation of about 12,000 feet. Moisture in this region is precipitated in the shape of snow which feeds our rivers all the year round.

2. The tract that bears the brunt of the severity of the monsoon is below 12,000 feet in elevation. An analysis of the rainfall data of the Southern slopes of the Himalayas enabled Hill(1) to draw up the following instructive table :—

Height above plain	Mean height feet	Rainfall ratio observed
0–1,000 ft.	435	1·61
1,000–2,000 ft.	1,300	2·65
3,000–4,000 ft.	3,350	3·91
4,000–5,000 ft.	4,750	3·46
5,000–6,000 ft.	5,710	2·20
6,000–7,000 ft.	6,370	1·89
10,000–11,000 ft.	10,660	0·12

It will be seen that the maximum rainfall occurs at an elevation of about 3,000 to 4,000 feet, progressively decreasing towards higher elevations. The variation is even more pronounced along the same latitude, the range being 25 (Srinagar) to 500 inches (Cherapunji) increasing eastwards. This vast quantity of water falling within limited time and confined to limited space becomes a serious menace due to the potential which the elevation of this region imparts to it. During the latter part of the monsoon months, viz., August and September, the Himalayan rivers are usually in spate and cause untold damage to the densely populated alluvial plains down below.

3. It will be seen that the severity of floods in this region is accounted by the following physical forces :—

(1) the periodicity in the rainfall,
(2) the intensity of rainfall in the Himalayan zone,
(3) the elevation of the zone.

It will be idle to delude ourselves into believing that these powerful physical forces can be controlled by mere artificial means deriving their inspiration solely from brick and mortar, cement and concrete. The situation recalls to one's mind the imperious fiat issued by Napoleon to construct a wall along the Atlantic ocean to arrest the progress of shifting sand dunes in the Landes near Bordeaux. The encroachment of sands had assumed such menacing dimensions that but for their successful fixation by exceedingly ingenious afforestation, we would have been faced with the spectacle of Paris itself being engulfed by sands to-day.

4. Physical forces are best controlled by physical means. The fact that the zone of the maximum rainfall supports luxurious tree-growth is no fortuitous coincidence. Nature is always in balance and maintains an equilibrium between opposing forces providing its own corrective against the forces it unleashes. Nature's sole provision against the development of devastating floods is the creation of vegetal cover. The effect of various types of vegetal cover in reducing run-off is illustrated *par excellence* by the following figures(2).

Kind of soil cover	Loss of precipitation in proportion of	Annual loss of soil per acre in proportion of
Forest with normal ground cover ..	1	1
Forest with poor ground cover	3	20
Well-managed pasture	3	14
Grassland	10	130
Completely bare ground	25	3,250
Agricultural crops	25	3,250

5. It is the high canopy of the forests with normal ground vegetation that constitutes the best soil cover for the conservation both of soil and moisture. The interposition of vegetal soil cover acts as a mechanical deterrent to the development of floods by :—

(1) preventing rain from reaching the ground, by keeping it in a suspended condition on foliage of trees. The bulk of these widely distributed rain drops on leaf-surface evaporates back into the atmosphere,

(2) increasing the vertical drainage of soil by virtue of the high absorption of humus layers and the increased porosity of such soils due to living root systems.

6. It is obvious, therefore, that well-wooded hill slopes have not only an appreciably smaller run-off, but what is of even greater consequence, the velocity of the flow also is considerably reduced. It is the velocity of a current that has an important bearing in the conservation of soil. It has been shewn that while erosion varies as the square of velocity, the power of transportation of eroded material varies as the sixth power of velocity. Thus, if the velocity of a stream is increased 10 times, the erosion will increase a hundred times, and the material transported a million times.

7. In any flood control measure to be devised, attention in the first instance should be focussed on the maintenance of the vegetal cover in the upper reaches of the Himalayas. And what is true of the Himalayas is equally true of other mountainous regions in the country. In the proper management of the catchment areas of large rivers lies our best security against the flood menace. The challenge of the millions of drops of rain can be met only by myriads of leaves.

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FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

BY PROFESSOR E. P. STEBBING, M.A.

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PART II

(*Continued from* The Indian Forester, *March 1951, page 175*)

HINDUSTAN

INDIA

(INDIA : now termed INDIA and PAKISTAN)

The shape of the Indian continent is usually considered to be triangular, with the Himalaya as its northern base and the sea on the other sides. Rhomboidal, more strictly defines the shape. The length of the north-eastern side of the rhomboid, from the head of the Bay of Bengal to the extreme north-west of Kashmir along the line of the Himalaya is about 1,400 miles ; from Kashmir to Karachi on the north-western side is about 1,200 miles ; Karachi to Cape Comorin running down the coast on the Arabian Sea on the south-west side of the rhomboid is 1,750 miles ; and from Cape Comorin up the east coast of Madras to the mouths of the Hooghly river is another 1,300 miles, washed by the Bay of Bengal.

The area comprised in this rhomboid omits Assam and Burma. An acute-angled triangle with a 300 mile base stretching up from the mouths of the Hooghly on the north-eastern side of the rhomboid and its apex situated 550 miles to the north-east will include Assam ; and an attenuated triangle stretching southward and eastward for 1,250 miles (all by rail) with its apex within two degrees of Cape Comorin and its base on the south-eastern side of Assam triangle will roughly include the province of Burma.

It is the existence of the mighty mass of the Himalayan bulwark stretching across the north and blocking it off from Central Asia which has conserved to India its distinctive flora and fauna and has been a determining factor in the history of the country.

To the north-east and north-west (the two northern sides of the rhomboid) are vast elevations of land surface from the foot of which the peninsula of India stretches away southwards in gradually ascending grades. To the north-east and north-west exist elevated regions of plateau and tableland buttressed by mountain systems which form the staircases between the plains and the plateau. On the north-east the huge upheaval of Tibet rising to 16,000 feet above sea-level, shuts off the rest of Asia with an unpassable barrier of sterile and stony uplands bordered India-wards by a vast mountain region which comprises many complicated minor systems whose central peaks are the highest in the world. These are the Himalaya. From the western extremity of the central Tibetan upheaval mountain ranges curving southwards determine the initial direction of the rivers of China, Siam, Burma and Assam, and round off the north-eastern borderland of India with a series of walls as impassable as the solid block of the Tibetan plateau. On the extreme north, abutting on the north-west of Kashmir, the Pamirs (well called the Roof of the World) flank the depression north of the

Tibetan plateau westward, and mark the geographical centre from which spring the Kuen Lun, hedging in Tibet to the north; the Himalaya dividing Tibet from India; the Thian-shan, which are but the south-western links in the central orographical axis of Asia, which reaches north-east for 4,600 miles to the Behring Straits; and the Hindu Kush, with its subsidiary ranges, forming the north-western barrier of India.

To the south of the region of mountains is the region of depression which lies at its south-eastern foot, curving northward across the breadth of the peninsula from the Bay of Bengal (on the east) to the Arabian Sea (on the west), and including all the most fertile and densely populated districts of Hindustan. This is the great silt-formed land of India, the land of great rivers which flow through the Himalaya and the western mountains, bringing the soil of Tibet, of Afghanistan and Baluchistan to fertilize the land and nourish the Punjab and Sind. In this area of depression (never rising more than a few hundred feet above sea-level and often only a few inches above) we must include Assam, the valley of the Brahmaputra. It may be noted here that all the three great river systems of India—the Indus, the Ganges and the Brahmaputra—derive a part of their water supplies from the sources which lie in the highlands beyond the Himalaya and the western mountains, and part from the countless valleys which lie hidden within the mountain folds.

To the south of the area of depression succeeds the region of southern tableland, or peninsular area, which includes the Central Provinces, Bombay, Madras, Hyderabad, Mysore, Travancore and several other minor states and provinces. This three-sided tract of territory, known to the ancients as the Dakshin (Deccan) or 'south land' supports a population of about two-thirds the strength of the population of the depression, and by the Eastern and Western Ghats of the Madras and Arabian Sea coasts respectively; the two latter running to an angle near Cape Comorin.

South of the Himalaya, India may be divided roughly into two parts: firstly, the area embraced by the great alluvial plains of the north, which include the Punjab, Rajputana and Sind on the north-west, the United Provinces in the centre and a great part of the Bengal province with the deltas of the Brahmaputra and the Ganges on the north-east; and secondly, the highlands of Central India and the low alluvial tracts of the south. The great northern area of low-lying plain reaches from the Himalaya to the Indian Ocean on the west, and to the Bay of Bengal on the east, and includes the main arteries of the great river systems of the Indus, the Ganges and the lower Brahmaputra. In Strachey's *India* we read:

> "The Indo-Gangetic plain comprises the richest, the most fertile, the most populous, and historically the most famous countries of India. It covers more than 500,000 square miles, an area as large as France, the German and (late) Austrian Empires and Italy, and it contains 160 millions of people..... The alluvial deposits of which it is composed, are so comminuted that it is no exaggeration to say that it is possible to go from the Bay of Bengal up the Ganges, through the Punjab, and down the Indus again to the sea, over a distance of 2,000 miles and more, without finding a pebble, however small".

Differing widely in its physical characteristics from Northern India, the second great natural division comprises the provinces of Madras and Bombay, the Central Provinces and some of the chief native states of India in the centre and south. It is separated by no sharply defined line from the north, the plains of the northern states gradually rising in broken and irregular steps to the crest of the Vindhya and Satpura Mountains, and maintaining an average of 1,500 feet south of the Narmada river across the central tableland to Mysore, where it

attains to 3,000 feet or more. These central highlands which include vast primeval forests covering rugged hill tracts intersected by wide valleys with gentle slopes, is depressed towards the east, and is bounded on either side by well-defined ridges of higher altitude, which appear as ranges when viewed from the sea, and follow approximately the line of coast curvature, leaving a broad strip of level coast between their lower spurs and the sea. These bounding edges of hill country are termed the Eastern and the Western Ghats respectively. The plateau slopes to the east and south-east, so that the Eastern Ghats are of no great altitude, being about 1,000 feet above sea-level, and there is little or no fall from their crests westward, but the Western Ghats adopt the formation of a distinct anticlinal with more decision ; and though irregularly piled together where they first commence to take shape south of the Nerbuda, they gradually consolidate and finally rise to an altitude of nearly 8,000 feet in the south, where they culminate in the Sispara peaks of the Nilgiris. The deep blue tone assumed by these magnificent grass-covered hills, when the south-west monsoon sweeps across their crests. and breaks on their western slopes, gives peculiar force to the name—Nilgiris, or Blue Mountains. South of the Nilgiris, the Western Ghats continue in the formation of a mountain range, receding, however, from the coast, and leaving the low level State of Travancore between themselves and the sea, until they terminate near Cape Comorin.

The Eastern Ghats commence to round off westward from a point not far north of Madras, and with broken outline fall back from the coast until they merge into the southern buttresses of the Nilgiris, leaving the broad plains of the Carnatic to stretch almost unbroken to the Bay of Bengal.

To the north of the line of the Western Ghats, but thrown back at an angle which gives them a north-easterly and south-westerly trend, is an isolated range, flanking the eastern deserts of Rajputana and dividing them from the native states of Central India, called the Aravalli Range, the primeval range of India. Mount Abu (the highest point of the range) is 5,000 feet above sea-level, an altitude which ensures a climate suitable for the small hill-station which occupies the highest slopes and clusters round the ancient rock-cut temples, overlooking vast stretches of plain to east and west. The Aravalli is but the most southern link of a great system in which straight rocky ridges, more or less isolated by stretches of intervening sand, follow the same strike and crop up in parallel lines of small elevation through the length of Eastern Rajputana. In general appearance this formation is that of a range, connected and continuous, but which has been overwhelmed by an encroaching sand sea. The flood of sand has filled up its valleys, and drifted in long, smooth slopes against its crest until it has left nothing but lines of narrow, jagged peaks to mark its position. The Vindhyas, the Aravalli range, the Western Ghats and the Nilgiris, with the final southern extension culminating in the Anaimalai hills, are the chief mountain masses of the Indian Peninsula south of the Himalaya. Hidden amongst them are many spots of rare beauty, many a group of magnificent peaks clothed with an infinite variety of forest vegetation, the recesses of which are known probably only to the district official, the Forest Officer, or the sportsman.

The River systems of India, excluding Assam and Burma, may be grouped as follows :—

(1) The Indus system on the north-west—Beas, Sutlej, Ravi, Jhelum, Chenab.

(2) The Ganges and Brahmaputra to the north-east.

(3) The Nerbuda, Tapti, Son and Mahanadi in the central group.

(4) The Godavari, Krishna, Cauvery and others in the southern system.

Statement showing the length of Main Rivers in India, excluding Pakistan, and the areas of their catchment

Particulars of the region	Name of River	Length of River in miles	Catchment Area in sq. miles	Remarks
I. Rivers falling into Arabian Sea (excluding the Indus system)	Tapti ..	464	25,000	
	Narbada ..	800	33,750	
	Mahi ..	286	13,450	
	Sabarmati ..	240	8,370	
	Luni ..	336	24,750	
II. Indus basin in India	Sutlej ..	592	118,974	Up to Pakistan border.
	Sutlej ..	907		Up to junction with Indus.
	Beas ..	223	17,699	Up to junction with Sutlej.
III. Rivers falling into Bay of Bengal (other than Ganga and Brahmaputra system)	Cauvery ..	440	31,800	
	Pennar ..	355	20,575	
	Bhima ..	459	26,511	Up to junction with Krishna.
	Tungabhadra ..	394	27,178	
	Kistna ..	810	44,011	
	Manjora ..	377	11,900	Up to junction with Godavari.
	Penganga ..	413	19,000	Up to junction with Wainganga.
	Wainganga ..	415	24,000	Up to junction with Godavari.
	Indravati ..	281	16,000	Do.
	Godavari ..	850	38,400	
	Mahanadi ..	540	51,270	
	Brahmani ..	281	11,700	
	Baitarani ..	207	10,000	
	Suharmerekka	255	13,700	
IV. Ganga (Ganges) system	Damodar ..	300	9,000	
	Ramganga ..	298	5,500	Up to junction with Ganga.
	Banas ..	327	18,860	Up to junction with Chambal.
	Chambal ..	540	3,900	Up to junction with Jumna.
	Jumna ..	809	46,750	Up to junction with Ganga.
	Sone ..	459	25,550	Up to junction with Ganga.
	Goghra ..	642	30,200	Do.

(*contd.*)

Statement showing the length of Main Rivers in India, excluding Pakistan, and the areas of their catchment—(concld.)

Particulars of the region	Name of River	Length of River in miles	Catchment Area in sq. miles	Remarks
IV. Ganga (Ganges) system	Gandak ..	363	14,500	Up to junction with Ganga.
	Kosi ..	455	22,988	Do.
	Ganga ..	1,114	32,300	Up to Pakistan border.
	Ganga ..	1,452	32,500	Up to out-fall.
V. Brahmaputra system	Tista ..	259	13,750	Up to junction with Brahmaputra.
	Subansiri ..	316	10,700	Do.
	Benas ..	292	14,510	Do.
	Brahmaputra ..	1,599	35,000	Up to Pakistan border.
	Brahmaputra ..	1,758	131,500	Up to junction with Ganga.
		20,908 miles		

ASSAM AND BURMA

ASSAM

Their geographical features are of interest. On the north the valley of Assam lies under the eastern ridges of the Himalaya, which here comprise Bhutan and the outlying border of Tibet, and includes up to recently some of the most irreclaimable and uncivilized of Himalayan tribes. On the South, the rough tableland of the Garo, Khasi and Jaintia Hills intervenes between the valley and the Cachar districts of Eastern Bengal drained by the Surma, here the Surma joins the Brahmaputra after the latter has turned the western flank of the hills. Assam is the valley of the Brahmaputra and it owes its wealth of agricultural resources—even its very existence—to that silt-bearing river. The Brahmaputra rises, like the Sutlej, near the sacred lake of Manasarowar. For 800 to 900 miles it flows steadily eastward through Tibet as the Tsan-po, passing to the south of Lhasa, the Tibetan capital. Then, turning the eastern flank of the Himalaya, and receiving a few Chinese tributaries, it twists into Assam under the name of the Dihang. At this eastern bend it takes up the Dibang from the north and another stream (which is also named Brahmaputra) from the east, and finally, as the "Son of Brahma, the creator" (i.e., Brahmaputra), it proceeds to increase and fertilize the valley of Assam. Its drainage basin is 361,200 square miles, and its mean low-water discharge at Goalpara, near the head of the valley, amounts to 116,500 cubic feet per second. After receiving the Subansiri from Tibet, the total flood discharge must be over 500,000 cubic feet.

The Brahmaputra rolls down the Assam valley in a vast sheet of water, broken by numerous islands, and exhibiting the operations of alluvion and deluvion on a gigantic scale. The vast quantity of silt brought from the Himalaya is deposited in banks at the smallest obstruction, and islands form and reform in constant succession. Broad channels break away, and rejoin the main river after wide divergences which are subjected to no control. The swamps which closely adjoin the elevated alluvial foundation of the river bed are flooded

in the rainy season till the lower reaches of the valley are one vast shining sea, from which the hills slope up on either side. After 450 miles of open course the river turns the western flank of the Khasi hills. Here it becomes the Jamuna for 180 miles of southerly flow across the flat plains of Bengal till it joins the Ganges at Goalanda. Then the deltas unite. After the Surma has joined from Cachar the united stream of the three great river systems takes the name of Meghna and rushes to the sea. At Calcutta it is known as the Hooghly. Goalpara and Dibrugarh are perhaps the best known stations of the upper Assam valley, and on the Khasi hills to the south stands the well-known hill sanatorium of Shillong.

BURMA

Lastly, there remains Burma to be described. Burma the land of picturesque rivers and forest-clad mountains. Burma is shut off from Assam on the north-west by a mass of densely forest-covered mountains, running in steep and high ridges intersected by deep and narrow valleys, inhabited by the tribes of the aboriginal inhabitants of the north-east frontier ; Singphos and Nagas on the north, Karens farther to the north-east, Lushais and Chins on the north-west ; all of them secure in their almost impenetrable jungles, through which a right of way was made during the last Great War.

This formerly little-known tract of country is perhaps the most interesting in India from the faunistic and botanical point of view.

This stretch of impassable hills is more or less continuous down the whole southern watershed of the Assam valley ; it envelopes the little independent state of Manipur, and reaches into the Khasi and Garo plateau north of Sylhet and Tepperah to the west. One long arm stretches away southwards and gradually separates the coast district of Arakan from the interior of Burma. The extreme north of Arakan is lost in the southern abutments of the long parallel mountain ridges of Lushai, which runs from north to south and end on the sea-coast ; whilst to the west are the Chittagong hill tracts and coast district. South of this, about the debouchment of the Arakan river (the Koladyne), which joins the sea near the trading port of Akyab, there is a stretch of coast lowland some 40 miles or so in width. Then this southern arm of the mountains becomes definitely detached as a single range, and strikes southwards, approaching nearer and nearer to the coast, narrowing the width of the Arakan lowlands until it ends as a barren red rocky ridge at Cape Negrais. This is usually known as the Arakan range. The chief pass across it is the Aeng, of which the summit is about 5,000 feet above sea. The western spurs of the mountains are covered with forests of fine timber, but on the east, where the range breaks down to the level of the Irrawaddy valley in a succession of minor parallel ridges, bamboo is the principal growth.

East of the Arakan range are the great central plains of lower Burma, watered by the Irrawaddy and the Sittang. East of this again, extending through Burma from north to south, we find broken highlands and plateau, traversed by no definite mountain ranges, but forming one continuous chain of rugged tableland, stretching from the Kachin hills on the north, through the northern and southern Shan States to the Karenni country on the south. This tableland is intersected by the trough of the Salween river. Beyond the Shan States is China in the north and Siam in the south. But the province of Burma does not end with the Shan States. There is a long strip of coast land, averaging perhaps 20 miles in width, but occasionally narrowing to 10, which extends down the western edge of the Malay peninsula, and includes the districts of Marteban and Tenasserim with Moulmein as the chief town. This is also part of the province under the administration of the Governor of Burma. It includes the Mergui archipelago and is chiefly remarkable for the long broken coast line, extending through 16 degrees of latitude, flanked by hundreds of islands which once formed

part of the peninsula. The total length of Burmese coast-line from North Arakan to South Tenasserim is not much less than 550 miles. The total area of the province is 171,500 square miles.

Climate and Rainfall

The rainfall of the continent has marked effects on the growth and types of forest present. Indian climates have marked characteristics, the feature of importance being the periodic rainfall or monsoons. The distribution and character of the various types of Indian forests are primarily influenced by the monsoon rainfall. The monsoons prevail at two seasons of the year. The first or south-west monsoon rains bring to an end the hot weather season, falling between June and September. They first strike and give rain to the whole of the lower western coast of the peninsula and the western coast of Bengal and Burma. The second or north-east monsoon falls between October and December, being chiefly confined to the eastern coast of the peninsula. Some parts of the country receive rain from one or other of the monsoons, other regions being affected by both. The south-west monsoon rains from the Arabian Gulf fall with their full force on the western coast districts from the Tapti southwards and the Ghat Range behind them ; as also on the coast lands and outer hill ranges of Tenasserim, Pegu, Arakan and Chittagong ; the plains of Bengal, the outer slopes of the Eastern Himalaya and the Khasi and Tipperah hills. This monsoon also reaches in a lesser degree the western slopes of the Himalaya, the whole length of the outer southern parts of this great mountain system also receiving a monsoon rainfall at this period from the rain clouds travelling up from the Bay of Bengal. The north-east monsoon rains, on the other hand, provide the chief rainfall of the coast of the Carnatic, from the Kistna river southwards and inland to the outer ranges of the hills of the Eastern Ghats ; of the Mysore tableland, the Javadi, etc., and even reach the edge of the Western Ghats. This region receives only a scanty and often failing supply of rain from the south-west monsoon. The regions which receive both monsoons are confined to the peninsula the inner areas of the Deccan and the Carnatic. In addition to the monsoons, varying amounts of rainfall due to local precipitations are received in different parts of the country, as for instance the so-called "Christmas Rains" in the United Provinces and elsewhere, the showers known as the Mango showers, and the local rainfall in Assam. These are often of very considerable local agricultural importance.

Omitting the part of the country in the south which is subject to two monsoons, the cold weather season commences in October or November (the former in the northern provinces) and lasts till the end of February or end of March respectively. This cold season is followed by the hot weather commencing in early March (or early April, the latter in the north) and lasting till the monsoon breaks in early June or July. It is during the hot season that the forests suffer so severely from fires ; though the modern fire conservancy arrangements introduced by the Forest Department have done much to mitigate this evil. This season is, however, a somewhat trying one for the Forest Officer.

(*This brief summary is based on Holdich's "India" published in 1904*).

Some points of the forest position and earlier invasions and their influence on the rivers may be given.

This successive waves of invasion and immigration into India had some effect on the forests. The Aryan invaders probably entered India some 2,000 years B.C. and they appear to have been an agricultural people. In order to carry on their persuits they commenced burning and clearing away the dense forests in the areas in which they settled in order to obtain land for the growth of crops and on which to graze their cattle. The ancient epic

Mahabharata tells of the burning of the great Khandava Forest. This forest appears to have been situated between the Ganges and Jumna rivers, and the description forms the first semi-historical evidence of the destruction of the forests by the early settlers.

The legend relates that the burning of the forest was only carried out with great difficulty owing to the frequent rains which Indra poured down to quench the fire. Allusions are numerous in the epic to dark and gloomy, and we may be sure dense and tangled forests as still covering large portions of the country even within what are now the drier zones along the banks of the Jumna. But it is also made evident in the epic that in other parts the early settlers had already cleared large areas for cultivation, etc., in those ancient times and that a terrible drought and famine had devasted the country, dreaded experiences which were doubtless reproduced more than once. For in the second epic, the *Ramayana*, dating from the time when an Aryan Empire was established in Oudh, there are allusions to severe droughts, and Sringa, the forest-born, is worshipped as the bringer of rains. Forests, dark as a cloud and very dense in the wilderness of Taraka, are spoken of here.

At the time of the invasion of Alexander the Great (about 327 B.C.) the forests in the north of the Punjab were still dense, in spite of this being the part of the country in which the Aryan invaders first developed a stable Government. For we are told that the Salt Range and the country on the banks of the Jhelum were clothed in forests dense enough to conceal the movements of Alexander's armies. Those who accompanied Alexander kept careful notes of the regions he operated in, and in his history of the invasion, Arrian, in describing the march east of the Jhelum, says that the forests there extended over an almost boundless tract of country, "Shrouding it with umbrageous trees of stateliest growth and of extra-ordinary height ; that the climate was salubrious, as the dense shade mitigated the violence of the heat, and that copious springs supplied the land with abundance of water".

This description would seem to apply to the Pabbi and probably to the low lying country between that range and the Chenab, over the southern portions of which *Dalbergia sissoo* and *Acacia arabica* are still to be found scattered. The evidence is of importance for Arrian describes the high *ber* (i.e., the high plains tableland between the two rivers), lands of the Punjab west of the Ravi—the Rechnat Doab—as in much the same state as when the British entered the Punjab some twenty-one centuries later. It is our great new irrigation system which has since turned much of this into valuable agricultural properties.

It appears probable that during the whole of the Brahmin and Buddhist periods, forests still existed over a considerable part of India adapted to the growth of such, the valleys and land areas adjacent to the larger rivers being under an intensive cultivation. The great reduction in the forest areas in the country was slowly brought about by the constant invasions of the Central Asian peoples who brought their flocks with them ; and as both people and flocks increased in numbers, wider and wider areas of forest were burnt and destroyed to obtain pastures for them. This period may be said to have culminated with the Mahomedan conquest, commenced 8th century A.D., of a large portion of India. The Mahomedan had no regard for the forests, nor any religious scruples about destroying them. Rather, he was taught that the forest was a free gift of Nature and belonged to anyone, just as water did. The destruction, therefore, proceeded apace. India suffered from Mahomedan incursions just as Persia, Asia Minor, Spain and other countries on the Mediterranean suffered. But a part of the destruction of the forests was probably carried out by the original agricultural population who, under the ever increasing stream of invasion, were driven back into the forests and hills and mountains where they practised the method of shifting cultivation, which under various names had been practised in the forests of India during many centuries and still exists in some parts—a pernicious system which is probably as destructive to forests as any other act of man.

On the other hand, the planting of trees either for the fruit which they yielded or for the purposes of obtaining shade was an act which was held in high esteem in eastern countries, and especially in India, from very early times. The eastern appreciation of the luxury of shade led to the banks of the canals constructed by the Mahomedan Emperors, being planted and the waysides of the Imperial highways being lined with trees of various kinds. In the Sunnud of the Emperor Akbar, it is directed "that on both sides of the canal down to Hissar, trees of every description both for shade and blossom, be planted, so as to make it like the canal under the tree in Paradise ; and that the sweet flavour of the rare fruits may reach the mouth of every one, and that from those luxuries a voice may go forth to travellers calling them to rest in the cities where their every want will be supplied". (*Calcutta Review No. 23*).

That the wholesale destruction of forests has had a serious deteriorating effect on the climate of India is beyond all cavil. What may be termed the historical proof of this contention is furnished by the numerous deserted sites of old towns and villages, now represented by ruins of walls of mounds either buried in the sand of a desert or overgrown by dense jungle which indicate that the areas were once more or less densely populated, but where present day human activity is only represented by a scattered population and scanty agriculture. The desertion of these formerly populated areas has not been in the main, due to depopulation owing to invasion and extermination, nor was the cultivation due to extensive irrigation, for evidence of such works would have remained extant ; and there is no such evidence. The disappearance of the people of these old densely populated areas was mainly brought about by the reckless, continuous and wholesale burning of the forests which led to the gradual decrease of water in the larger rivers, to the drying up of springs, small streams and rivers, the lowering of the water-table in the soil and to a decrease in the rainfall of the country. This result was gradual, the war against the forests being spread over many centuries, probably 3,500 years or more ; for the Mahomedan rule alone had lasted 750 years at the time the battle of Plassey was fought and won by the English, and the invasions of India by the nomadic tribes from High Asia had continued for many centuries previous to the Mahomedan conquest of the country.

From what has been written above it will be seen that areas once under cultivation have in some cases, since relapsed into jungle again, become reafforested by Nature, in fact, thereby proving that if left undisturbed by man, areas suitable for carrying forests would soon become re-clad, given that the other necessary conditions were favourable. Numerous proofs that this is the case are to be seen in India, and many Forest Officers will have encountered one or more instances.

Ribbentrop (Inspector-General of Forests 1883–1900) mentions that throughout the Gumsur Forests in the Ganjam District very old mango and tarmarind trees are to be found in groups in the forests, now surrounded with sal trees, often of very fine growth and probably at least 200 years old. These clumps probably represent the sites of old villages in the area which was once under cultivation. Depopulation may have been due to the descents of the hill tribes (Khonds) of the neighbouring regions, or to drought and famine or pestilence and wild animals especially elephants. The people disappeared and the cultivated lands soon became covered with a fine crop of sal saplings. The writer has seen the same thing in Chota Nagpur and the Central Provinces, where the ruins of old buildings and tanks are not uncommon, now buried in a dense tangle of jungle affording homes to wild animals ; and in the Chittagong Hills the same ancient ruins of an old civilization may be seen.

Therefore, although it is certain that the area of forests in existence in the country at the present time is but a fraction of those standing in the early history of the country, and that the destruction of the greater bulk was resulted in a far hotter and more variable climate ;

yet evidence is not wanting that suitable areas throughout the country if left untouched by man would once again become re-clothed with forests.

The trouble arises in the drier districts where bare, hot deeply-seamed hill-sides, or great stretches consisting of a network of barren, hot ravines, once clothed with forest, now require to be reafforested in the interests of the people. Nature is unable to do this, and it becomes the work of the scientific Forest Officer to grapple with the problem.

The People and the Forests

As regards the habits of the people, when the British first commenced to govern India in the Madras and Bombay presidencies in the early years of last century, shifting cultivation was rife in the forests of both presidencies. At first little attention was paid to it as the whole country-side was considered to be covered with an inexhaustible forest. The only wood used here was the teak at this time. Gradually the increasingly heavy teak fellings in accessible forests brought about scarcity by the 1830's. Also the appalling waste being incurred by shifting cultivation had been studied. The Governments both in Madras and Bombay endeavoured to tackle these two matters. They were more successful with the shifting cultivation threat. By 1860 it may be said that this method of so-called cultivation was put down, but at that period a big list of small ports on both east and west coast had been silted up and put out of commission for even ships of small tonnage ; and big rivers like the Godavari were no longer suitable for raft floating since they dried off to such an extent in the hot season of the year. Gradually as British rule spread throughout India the Government of India realized with the increasing demands made on the forests and the careless way they were treated by the people that steps must be taken or the main forest property of the country which was at all accessible would be cut out with the most serious consequences to the population. An Indian Forest Service was created in 1864 and the business of reserving large forest areas, introducing rules to abolish unchecked fellings, prohibiting fires and so forth was in full force by the end of the century. It had also been learned that under certain conditions the mere closing of a badly overgrazed, hacked and heavily burnt area of forest would result in the forest recovering and becoming a good high forest again, with the natural event of restoring water supplies. By the end of the century the practice of shifting cultivation had been stamped out in India with the exception of small areas in Madras, in the Chittagong Hill tracts, in Bengal and in areas in NE. Assam ; and in these areas it was under control. In some provinces the method was used by the Forest Officer in what is known as the *taungya* method to replace the forest felled by a new crop, as detailed under Burma below, page 245.

In the more arid parts of India and in those which have been made so by man's action, e.g., on the hills on the east of Madras Presidency, the outer Punjab hills, and elsewhere the ordinary water difficulties of such regions are experienced. But they are nothing like those in many parts of Africa and have not so far got out of control to any extent—certainly not on the African scale of degradation.

The following information has been given to me (January 1950) by Mr. F. C. Osmaston late Conservator of Forests in Bihar and Orissa and now Lecturer in the Department of Forestry of Edinburgh University.

RIVERS IN BIHAR AND ORISSA

The Mahanadi

Rising in the Central Provinces the river flows into the Bay of Bengal via a delta that begins at Cuttack and is about 50 or 60 miles in length.

In Orissa the river is 300 miles long including its 60 miles of delta.

The country through which it flows in Orissa is forested to perhaps 35% of which at least 15% is open protected or unprotected forest overgrazed and deteriorating to scrub. Perhaps as much as 15% or more is reserved and well protected forest.

The majority of the cultivated land is terraced rice fields.

The Brahmini

This river rises in the border of Bihar or in Bihar by means of its upper tributaries, the Sankh and Kool, into which it forks.

Length :—Brahmini proper	..	270 miles (including its delta)
Sankh ..	..	125 miles
Kool ..	..	165 miles.

The Brahmini eventually flows into the Bay of Bengal via the Mahanadi delta.

The country through which it flows is afforested to about the same extent as the Mahanadi.

The Baitarani

Rising in Orissa on the border of Bihar about 30 miles from Chaibasa, this river flows into the Bay of Bengal.

Its length is about 185 miles and its catchment area is perhaps somewhat more forested than the Mahanadi.

The Subhanarakha

This river rises in Bihar near Ranchi and flows into the Bay of Bengal. One large tributary joins it at Jamahadpur flowing into it via Chaibasa.

Length—270 miles. Its tributary, Khorkai—85 miles.

The catchment area through which it and its tributaries flow is probably afforested only to about 10% of which 5% would be overgrazed unprotected and scrub forest almost useless for protection.

The Damodar

This river rises in Bihar between Ranchi and Palaman, flows through the Hazaribagh district into Bengal and so to Howrah and the Ganges delta.

Its length from source to Howrah is 350 miles and to the sea about 400 miles or more.

Its length in Bihar is about 175 miles.

In Bengal, over some 225 miles, there is little or no forest. In Bihar perhaps 15% or more of its catchment area is afforested. But of this probably only 5% is useful protection forest, the rest being overgrazed, overcut, pole forest or scrub that has belonged to Zamindari private owners.

Floods have been almost annual. Recently reservation of Private forests in Bihar has been started with the aim of reserving some 5,000 square miles. This is in collaboration with the dam and Damodar valley reclamation and electrification scheme.

The Ganges

This huge river rising in the Himalaya flows into the Bay of Bengal via its delta, below Calcutta. For about 175–200 miles it flows through Bihar. Probably not more than 5% of its catchment area (and that of its tributaries) carries forest. But I have little or no personal experience of it.

Note.—The lengths of rivers given above have been taken over a map and are, I hope, accurate within 10%. To obtain more accurate figures would be very lengthy proceeding.

Similarly to obtain lengths of more tributaries would also take much time. So only a few are given.

The figures of forested lands are merely personal estimates based on what I have seen and remember. They may be faulty.

Additional Notes by Professor E. P. Stebbing.—(continued)

In the first-half of last century 1800–1850 the chief interests of the Government lay in obtaining supplies of timber for building, military and naval, and other purposes.

The British rule over India started in the south in Madras, Bombay and Bengal and it is within these regions that the great demand for timber commenced. At the time it was thought that the forests were inexhaustible. Teak was the only timber used in the south. It was in the accessible Malabar forests in the west of Madras that most of the fellings fell, the demand being increased by demands from the Admiralty at home and private shipyards, a number of which existed on the coasts of England and parts of Scotland.

By 1940, the accessible teak forests in Madras were cut out though exploitable teak still remained in Travancore.

In North India the sal (*Shorea robusta*) was the chief and only timber used whilst in the Punjab the deodar (*Cedrus deodara*) brought down from the outer Himalaya was the chief timber used.

The increasing demand by both British and the native populations for firewood brought about a shortage of supplies, in this material and before the middle of the century both Madras city/ and the people on the country-side and those in the new hill station of Ootacamund and in other parts were complaining of shortage of fuel, the scrub areas of forest having been cut out and the roots grubbed up in the regions near the big towns.

The same complaints were occurring in the hill stations of Simla and Darjeeling.

These troubles and the obvious dangers accruing from unchecked fellings, unchecked shifting cultivation and the annual fires which spread over the country-side, forced the attention of the Government of India on these forestry questions and the Indian Mutiny (1857) may be said to have forced a climax and a settlement.

The newly appointed Secretary of State for India and the Governor-General decided on the formation of an Indian Forest Department with Sir Dietrich Brandis, the first scientifically trained man already in charge of the Burma Forests, as Inspector-General of Forests at its head. The Service came into being in 1864, a Conservator of Forests being appointed to the charge of the forests in each Province with a varying number of Assistant Conservators under him as District Officers. The enormous demand from the forests for sleepers, wood for building stations, and for fuel for the engines for the new railways fell upon the shoulders of the new Department. They acquitted themselves nobly and by 1870 had the lines of the new Department well laid down, with the accepted principle that over felling and unchecked fellings had ceased. The work up to 1900 was mainly concerned with the reservation of selected forests in the different Provinces, their demarcation, and so forth. This main work done, including the establishment of fire protection in all Government forests which had become a routine, the Department was able to deal, after 1900, with research and investigation work including the study of the silviculture of the chief species of trees, the preparation of temporary yield tables and so forth. A great Research Institute was built at Dehra Dun which carried out much good work both before and during the war.

It is of interest to note how this most efficient Forest Department was built up by the British Officers manning it over this period of time.

A point of major interest deals with the methods of management and working of the great teak forests of Burma. (See page 244).

Between 1871 and 1900 the chief matters of importance dealt with in the following order were : 1. Ownership of land ; 2. Forest Law ; 3. Forest Settlements ; 4. Demarcation ; 5. Forest Surveys ; 6. Education of Staff ; 7. Exploitation and Communications and Buildings ; 8. Protection (*a*) shifting cultivation, (*b*) fire protection, (*c*) grazing question, (*d*) erosion of hill slopes, etc., (*e*) protection from pests ; 9. Yield and Finance ; 10. Formation of Plantations and Improvement of Forest Crops ; 11. Introduction and Growth of Working Plans ; 12. Forest Literature. This definitely shows that the Indian Forest Service started with first things first.

Between 1901 and 1925 a change came about in the order. True forestry work could now be started and the programme was stressed as follows : 1. Administration ; 2. Education ; 3. Forest Research Institute and Research Publications ; 4. Fire Protection ; 5. Silviculture ; 6. Afforestation work ; 7. Forest Working Plans ; 8. Exploitation work of Department during the War ; 9. Modern Methods of Exploitation ; 10. Communications and Buildings ; 11. Yield Revenue from Forests and Expenditure ; 12. Aerial Survey work for forests.

There can be little doubt that the formation of the Indian Forest Department in 1864 not only saved the accessible forests in India from practical extinction by 1900, which would have been the result of the enormous increasing demands for timber grazing and so forth, but enabled the two wars of the 20th century to be fought and to some extent provided for from India, whilst enabling the population to obtain many ordinary household products, formerly imported from overseas, from the forests of the country.

In a report issued by the Inspector-General of Forests in 1944, it is shown that the area of Government forests in the country never properly distributed, is insufficient to provide for the greatly increased population. He says—

> "Although 20 per cent is probably a fair proportion of land under forest to fulfil the first two principles of India's forest policy, namely that necessary on climatic and physical grounds and for the general well-being of the country, it is really only 20 per cent in name. The private forests of India have been over-felled, and have been gradually depleted for many years.
>
> "The total yield of the forests of India in the period just preceding the war was approximatley 62 million cubic feet of timber and about 210 million cubic feet of fuel a year".

As regards War demands and fellings it is shown that though heavy they were under control—

> "So effective had been scientific forestry in the preceding seventy-five years that this excessive demand was met without material damage to the forests. It is of course, perfectly true that much of the excess fell on the best trees in the best areas and, from the revenue-producing point of view, the forests have been temporarily damaged for a few years. But from the point of view of the general use of the land and the good of the country, the forests have not been damaged seriously as forests. Part of the excess yield came from the use of inferior species, not previously considered of any value, the excessive demand enabling thinnings to be made which would have been too expensive in normal times. Though nobody would pretend that the war fellings had not been harmful, they were not an unmitigated evil. Their harm is only temporary and only from the revenue-producing point of view has any harm been done at all. Moreover, the final effects of the past eighty years of scientific management have not

yet been fully felt. It will not be for another twenty years, or a little more, that the first forest regenerated under care of the Forest Department will attain maturity, and the increase in yield which will then take place will be something far greater than anything which has been obtained in the past".

The chief present day trouble in India as in so many countries comes under the requirements of the local population for fuel. In parts of India, Bengal, e.g., there are no forests over large areas and for centuries the people have used for their fuel cowdung. The latter should have been put on the fields as Manure.

> "It has been calculated that in British India the cattle population is over 200 million and the cowdung of perhaps 85 million is burnt. This probably represents 60 million tons of dry manure per year, capable of producing somewhere about 345,000 tons of nitrogen, or sufficient to manure 13 per cent of the whole of India's cultivation".

It has always been considered that the primary forest problem of India

> "is not supply of the more expensive forms of timber, but the adequate supply to the villager on his doorstep of fuel and small timber to avoid this burning of cow-dung.
>
> "The provision of this supply is the crux of the problem of the forest resources of India. Adequate though they are in variety, in quality and even in quantity for the better demand, they completely fail in the more important matter of supplying village demand.
>
> "This is the main problem which the post-war Forest Policy of India proposes to tackle. Again taking British India alone, because adequate figures only exist for British India, it will be remembered that there are about 106,000 square miles of reserved forests and perhaps another 50,000 square miles of private forests, which latter are often little more than scrub. There are also roughly 145,000 square miles of what is cultivable waste and another 145,000 square miles of what is uncultivable waste. The present forest area of 106,000 square miles represents about 13 per cent of the total land area. Probably if 25 per cent of the total area were covered with forest, it would provide sufficient for the whole needs of the population, assuming that there was proper distribution".

It is laid down that a large scheme of afforestation should be started in the areas of India where the villagers have no wood fuel and that afforestation work on a large scale should be carried out which will mean the creation of new forests, fuel forests, over 100,000 square miles of land which will then be additional forest to that already in existence.

There are many regions of the world without Forest Services or any form of forest protection and management. I have, therefore, considered it useful to give here the method by which the great Forest Service in India was inaugurated and the results which have ensued in that great country of many different climates and geographical topography and soils.

For greater detail on the subject I would refer to the three volumes on "The Forests of India" written by myself and published between 1921–26.

Just as I had finished this paper on India as a whole, I received from Mr. C. R. Ranganathan, I.F.S., President of the Forest Research Institute and Colleges, Dehra Dun, India, the following account of the Rivers and their Catchment Areas of India and Pakistan which is valuable as it gives the latest information on the position of the catchment areas as known to date.

Statement showing the Hill Catchment Areas of the various Indian Rivers with the areas still under Forest in these Catchment Areas and the forest areas ruined through human misuses

Serial No.	River		Main or Tributary	Hill catchment area in sq. miles inside India and Pakistan, excl. Nepal and Bhutan	Area still under forest inside the hill catchment area (sq. miles)	Forest area ruined by human misuses (sq. miles)
	Name	Length (miles)				
1	Ganges ..	1,509	Main	8,620	4,090	630
2	Jamuna ..	800	Tributary	4,520	3,640	110
3	Ramganga ..	390	,,	3,350	2,870	340
4	Gogra	620	,,	5,150	2,420	180
5	Gandak ..	350	,,	1,760	30	1,210
6	Son	470	,,	16,970	12,690	3,000
7	Chambal ..	580	,,	36,460	21,850	10,230
	Total ..			76,830	47,590	15,700
8	Indus	1,830	Main	79,440	11,760	10,710
9	Sutlej	900	Tributary	12,660	3,110	760
10	Beas	220	,,	5,400	3,740	130
11	Ravi	420	,,	3,560	2,580	380
12	Chenab ..	640	,,	10,540	2,590	2,010
13	Jhelum ..	430	,,	16,280	10,520	1,250
	Total ..			127,880	34,300	15,240
14	Brahmaputra ..	1,800	Main	147,470	23,300	81,340
15	Mahanadi ..	550	,,	24,820	17,620	3,960
16	Godavari ..	898	,,	81,370	42,520	21,370
17	Krishna ..	680	,,	81,990	24,270	31,750
18	Cauvery ..	410	,,	23,280	12,910	5,700
19	Narbada ..	710	,,	26,610	17,280	5,130
20	Tapti	440	,,	13,120	7,200	3,260
	GRAND TOTAL ..			603,370	226,990	183,450

In April–May 1950 I received, through the kind auspices of Sri M. D. Chaturvedi, I.F.S., Inspector-General of Forests, some valuable statements giving valuable data on (1) Catchment Areas of Madhya Pradesh (2) Catchment Areas and chief rivers and tributaries of the Madras Presidency and (3) Catchment Areas, chief rivers and their tributaries and place of origin in the Bombay State, the latter two sent by the Chief Conservators of the regions through the Inspector-General of Forests.

An examination of these tabular statements will give evidence of the very considerable amount of data respecting rivers and water supplies and existing forests on the Catchment Areas over 80 years of Forest Management in India and Pakistan have made it possible to collect. The results of this forest reservation and protection throughout the whole country are clearly shown in the statements.

Statement showing the Catchment Areas of Madhya Pradesh

Catchment	Main River	Approximate length in miles from source to Madhya Pradesh border	Tributaries	Approximate length in miles from source to where they join the Main River	Forest Division involved	Govt. Forest area under catchment as per question Nos. 3 and 4
1	2	3	4	5	6	7
						sq. miles
1. Narmada catchment	Nermada	560	1. Banjar ..	100	Mandla ..	1,429
			2. Burhner ..	86	Balaghat ..	523
			3. Hiran ..	86	Jubbulpore ..	949
			4. Sher ..	50	Seoni ..	373
			5. Shakkar ..	60	Hoshangabad ..	1,024
			6. Dudhi ..	65	Betul ..	652
			7. Tawa ..	100	Nimar ..	605
			8. Ganjal ..	50	Total ..	5,555
			9. Chhotey Tawa	85		
2. Tapti catchment	Tapti	200	1. Purna ..	152	Nimar ..	1,071
			2. Murna ..	62	Betul ..	391
			3. Katapurna	70	Amraoti ..	1,057
					West Berar Div.	562
					Total ..	3,081
3. Godavari catchment	Godavari	42	1. Penganga ..	382	W. Berar Div. ..	188
			2. Wardha ..	282	Yeotmal ..	1,170
			3. Wainganga	360	Amraoti ..	353
			4. Pranhita ..	70	Seoni ..	552
			5. Indravati ..	200	Bhandara ..	568
			6. Kanhan ..	132	N. Chanda ..	1,265
			7. Pench ..	130	S. Chanda ..	1,221
					Chhindwara ..	662
					Nag. Wardha ..	714
					N. Bastar ..	8,872
					S. Bastar ..	
					Betul ..	121
					Balaghat ..	398
					Total ..	16,084

(*contd.*)

Statement showing the Catchment Areas of Madhya Pradesh—(concld.)

Catchment	Main River	Approximate length in miles from source to Madhya Pradesh border	Tributaries	Approximate length in miles from source to where they join the Main River	Forest Division involved	Govt. Forest area under catchment as per question Nos. 3 and 4
1	2	3	4	5	6	7
						sq. miles
4. Mahanadi catchment	Mahanadi	250	1. Sheonath ..	160	S. Raipur ..	514
			2. Husdo ..	170	N. Raipur ..	969
			3. Maniari ..	75	Bilaspur ..	789
			4. Arpa ..	82	Keria ..	895
					Surguja ..	462
					Raigarh ..	1,187
					Jashpur ..	1,125
					Drug ..	833
					Kankar ..	400
					Total ..	7,174
5. Ganga catchment	Betwa	30	1. Bina ..	42		
			2. Dhasan ..	89		
			3. Sonar ..	120		
			4. Bewas ..	86	Saugor ..	1,083
			5. Bearma ..	80	Jubbulpore ..	214
			Chhotey Mahanadi	110	Koria ..	896
			Katni ..	40	Surguja ..	3,250
					Total ..	5,442
					GRAND TOTAL ..	37,336

Note.—(1) Madhya Pradesh is divided into 5 catchment areas :—
1. Narmada. 2. Tapti. 3. Godavari. 4. Mahanadi. 5. Ganga.
(2) Areas of private forests are not available but most of them are in degraded condition.

Statement showing the chief rivers and their chief tributaries in the Madras Presidency, with their forest catchment areas

Serial No.	Name of Chief Rivers	Distance within the Province in miles	Chief Tributaries	Distance (within the Province) to where they join the Main River in miles	Amount of forests still standing on the upper reaches in the mountains and hills from their source down	
					Main Rivers	Main Tributaries
1	2	3	4	5	6	
					sq. miles	sq. miles
1	Godavari .. .. (Source outside the Province)	250	Taliparu ..	15	..	..
			Sabari ..	24	..	..
2	Krishna .. .. (Source outside the Province)	308	Tungabadra ..	260	..	..
			Hagari ..	104	..	..
3	Pennar .. .. (Source outside the Province)	328	Cheyyar ..	112	..	624
			Papagni ..	98	..	126
			Chitravathi ..	128	..	378
			Kunderu ..	128	..	844
			Sagileru ..	96	..	551
4	Palar .. .. (Source outside the Province)	164	Ponnai Ar ..	56	..	..
			Kavundinya Nadi	48	..	..
			Malattar ..	30	..	301
			Cheyyar ..	87	..	295
5	Cauvery	426	Kabbani ..	20	..	265
			Bhavani ..	200	..	1,009
			Noyil	100	..	100
			Amaravathi ..	120	..	290
			Other minor tributaries.. ..	..	..	2,319
6	Vaigai	200	Suruliyar ..	45	..	65
			Pambar ..	25		
			Manjalar ..	35	..	110
			Maruthanadiar ..	35		
7	Tambraparani ..	75	Chittar ..	75	135	15
			Manimuthar ..	36	..	60
			Packaiar ..	28		
8	Ponnani	130			230	
9	Chaliyar	96			125	
10	Valapattam ..	88			22	
11	Netravathi ..	70			310	

Statement showing information in respect of water supplies and

Serial No.	Name of the Chief River	Total length from source to mouth miles	Place of origin	Name of the sea into which the river flows	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
1	2	3	4	5	6	7	8
1	Tapti ..	450	Mahadeo Hills in Satpura mountain Betul District in Madhya Pradesh	Arabian Sea	20,000	130,000	150,000
2	Ambika ..	80	Hills of Dangs	Arabian Sea	1,000	5,000	6,000
3	Sabarmati ..	200	Aravali Hills	Arabian Sea Gulf of Cambay	150	200	350
4	Cauveri ..	32	Near Mankhuria village of Bansda taluka	Arabian Sea	..	10	10
5	Kim ..	60	Kodar hill	Arabian Sea	400	10	410

catchment areas as they apply to the Forests in the Bombay State

Serial No.	Name of the chief tributaries	Total length Miles	Place of origin	Place where it joins the Main River	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
9	10	11	12	13	14	15	16
1	Anjani ..	25	Hills of Nanebhal	Meets Tapti near Gasia Medha village	13,000	13,000	..
2	Nessu ..	60	Hills of West Khandesh	Narayanpur, taluka Navapur, Dist. West Khandesh	..	32,000	32,000
3	Purna ..	30	Gavilgad Chikhdara in Satpura Mt. in Berar	Changdeo in Edlabad Petha in East Khandesh Dist.	..	40,960	40,960
4	Girna ..	115	Near village Chirai in Kalwan taluka, Dist. Nasik	Palsod village in Jalgaon taluka, East Khandesh Dist.	239,000	105,266	344,266
5	Aner ..	100	Satpura Mt. in Nemad Dist. in Madhya Pradesh	Chinchkhed, taluka Amalner, Dist. East Khandesh	2,000	322,778	324,778
6	Vaghur ..	60	Ajantha Hills in Jizam State	Bhankheda, taluka Jamner, Dist. East Khandesh	..	68,480	68,480
7	Bori ..	40	Satpura Mt. in West Khandesh Dist.	Vichkheda, taluka Amalner, Dist. East Khandesh	..	42,880	42,880
8	Zankhari ..	20	Dang hills	Meets Purna river at 10 miles from Valod	5,000	10,000	15,000
9	Amravati ..	31*	Badwani State	Vanawal	5,000	104,033	109,033
10	Gomti ..	41	Gadhaddeo Forest settlement in West Khandesh Dist.	Prakasha in West Khandesh Dist.	13,000	62,021	75,021
11	Ajana ..	30	Sugalvin in Nanchal Forests	Kharvada to Tapti river	80	20	100
1	Gira ..	30	Dang Hills	Near Satsilla village	1,000	5,000	6,000
2	Olan Khadi ..	30	Bansda Hills	Between Sarsia and Velanpur villages	4,000	12,000	16,000
1	Harnav ..	..	Aravali Hills	Bhanpur	10	32	42

* Lengths of the river in the North-Eastern Circle of this Province. Total length not known.

Statement showing information in respect of water supplies and

Serial No.	Name of the Chief River	Total length from source to mouth Miles	Place of origin	Name of the sea into which the river flows	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
1	2	3	4	5	6	7	8
6	Narmada ..	500	Amarkantak	Arabian Sea	12,000	83,456	95,456
7	Mahi ..	250	Vindhya Mountains	Arabian Sea	3,000	12,000	15,000
8	Saraswati ..	150	Koteshwar	Disappears in the run of Kutch	12,800	53,760	66,560
9	Godavari ..	35	Trimbak	Bay of Bengal	..	5,080	5,080
10	Vaitarna ..	80	Trimbak	Arabian Sea	..	61,723	61,723
11	Ulhas ..	64	Rayaghad Rajmachi, Kolaba Dist.	Arabian Sea	9,600	35,200	44,800
12	Kalu ..	40	Ajaparvat, Taluka Shahapur	Arabian Sea	1,280	24,200	25,480
13	Bhima ..	180	Bhima Shankar	Joins Krishna river	..	9,506	9,506

catchment areas as they apply to the Forests in the Bombay State

Serial No.	Name of the Chief Tributaries	Total length Miles	Place of origin	Place where it joins the Main River	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
9	10	11	12	13	14	15	16
1	Udai ..	35	Kathi State, West Khandesh Dist.	Bhusha	12,000	91,008	103,008
2	Orsang ..	200	In the Malva Hills	Near Karnari	2,000	8,000	10,000
3	Karjan ..	40	Sarapada in Broach Dist.	Vyas Bet of Narbada river	200	200	400
1	Panam ..	100	In Central India Hills	Near Lunawada	1,000	4,000	5,000
1	Umerdashi ..	30	Godh Hills	Tokaria	2,560	5,120	7,680
1	Pinjal ..	44	Shirghat Mokhadi Petha	Near Vikas in Vada taluka, Dist. Thana	..	930	930
2	Deharja ..	33	Juna Jawhar taluka, Jawhar Dist. Thana	Tamboolpada, taluka Vada, Dist. Thana	..	2,036	2,036
3	Tansa ..	30	Tansa Lake in Shahapur taluka, Thana Dist.	Umbarpadi in Bassein taluka, Thana Dist.	..	39,513	39,513
4	Surya ..	48	Jawhar Dist. Thana	Dahisar, Dist Thana	2,560	640	3,200
5	Susari ..	13	Dhariwari Dist. Thana	Chinchora Dist. Thana	..	960	960
1	Chilar ..	20	Bhima Shankar	Kolhar	11,520	7,680	19,200
2	Barni ..	16	Shidgad, taluka Murbad, Dist. Thana	Apti, taluka Kalyan, Dist. Thana	..	900	900
1	Bhalsa ..	32	Dand, taluka Shahapur, Dist. Thana	Songed, taluka Bhiwandi, Dist. Thana	..	62,336	62,336
1	Dadhar ..	20	Khareshwar	..	..	11,236	11,236
2	Kukdi ..	60	Kukadeshwar	..	..	11,264	11,264
3	Meena ..	40	Durgkilla	Namvij	..	9,950	9,950
4	Ghodnadai ..	100	Ampe	..	..	31,693	31,693
5	Velnadi ..	36	Kuruwandi	Sangawi Savdas	..	885	885
6	Bhama ..	40	Wandra	Pimpalgaon	..	8,194	8,194
7	Indrayani ..	40	Andhra (Saloa)	Apli	..	15,618	15,618
8	Pawana ..	34	Lohagad	Dapoli	..	8,818	8,818

Statement showing information in respect of water supplies and

Serial No.	Name of the Chief River	Total length from source to mouth Miles	Place of origin	Name of the sea into which the river flows	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
1	2	3	4	5	6	7	8
13	Bhima—(*contd.*)						
14	Krishna ..	800	Mahableshwar	Bay of Bengal	999,521	20,420	1,019,941

catchment areas as they apply to the Forests in the Bombay State

Serial No.	Name of the Chief Tributaries	Total length Miles	Place of origin	Place where it joins the Main River	Catchment area: Denuded of Forests Acres	Catchment area: Still under Forests Acres	Catchment area: Total Acres
9	10	11	12	13	14	15	16
9	Mula* ..	80	Near Ambadara	Rangangaon	6,446	9,070	15,516
10	Mutha* ..	80	Timghar	..	..	12,959	12,959
11	Kanand† ..	30	Mohori	..	10,000	1,178	11,178
12	Nira ..	120	Shirgaon	Nera-Narsingpur	11,433	3,871	15,304
1	Kudli ..	18	Near Kalamb in Jawali taluka, Satara Dist.	Near Panchwad in Wai taluka, Dist. Satara	123,200	1,250	124,450
2	Yenna or Verma	40	Mahableshwar	At Mahuli in Satara taluka	260,090	1,890	261,980
3	Urmodi ..	20	Near Kas in Jawali taluka, Satara Dist.	Near Wanegaon, Satara Dist.	142,000	1,205	143,205
4	Taroli ..	22	Near Tarala village, Patan taluka, Satara Dist.	Umbraj, Karad taluka, Satara Dist.	162,800	1,330	164,130
5	Koyana ..	80	Mahableshwar	At Karad	378,200	4,086	382,286
6	Varna ..	50	Valva village, Satara Dist.	Near Sangli, Satara Dist.	408,600	2,510	411,110
7	Vasava ..	20	Near Solshi, Koregaon taluka, Satara Dist.	Mangatpur, Koregaon taluka, Satara Dist.	132,200	404	132,604
8	Yerala ..	75	Solakhanath hill, Khatav taluka, Satara Dist.	Near Bhilawadi, Satara Dist.	412,100	206	412,306
9	Panchganga ..	50	Sahyadri hills	Narobachiwadi	..	..	..
10	Bhogwali ..	50	Do.	Prayag Panchganga	128,000	6,400	134,400
11	Tulshi ..	15	Do.	Bhogwati	10,240	5,120	15,360
12	Kumbhi ..	20	Do.	Songrul (Bhogwati)	15,360	7,680	23,040
13	Kasari ..	35	Do.	Prayag Panchganga	37,120	24,560	61,680
14	Dudhaganga ..	55	Do.	Joins Wedganga at Bhoj Baswad	10,240	5,760	16,000
15	Wedganga ..	75	Do.	Joins Krishna near Bhoj Baswad	25,600	12,800	38,400
16	Warma ..	80	Do.	Near Haripur	16,640	9,160	25,800
17	Hiranayakeshi	70	Do.	Joins Ghatprabha river	25,600	12,800	38,400

* These rivers join at Poona.
† The river mainly forms the catchment area of Bhatgar lake and joins Nira at Bhor.

Statement showing information in respect of water supplies and

Serial No.	Name of the Chief River	Total length from source to mouth Miles	Place of origin	Name of the sea into which the river flows	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
1	2	3	4	5	6	7	8
14	Krishna—(*contd.*)						
5	Patalganga ..	48	Khandala	Arabian Sea	25,600	31,360	56,960
16	Kundlika ..	62	Bhira	Arabian Sea	32,000	8,960	40,960
17	Savitri ..	131	Ghol	Arabian Sea	6,400	12,800	19,200
18	Amba ..	58	Bhatgar	Arabian Sea	16,000	19,840	35,840
19	Terekhol ..	40	Shrisinge	Arabian Sea	117,908	10,329	128,237
20	Karli ..	50	Mandali in Kolhapur	Arabian Sea	132,242	4,489	136,731
21	Gad ..	47	Kumblavadi	Arabian Sea	54,600	..	54,600
22	Tilari ..	35	Ghotatre, Belgaum Dist.	Arabian Sea	60,740	4,459	65,199
23	Talaode ..	20	Malgaon	Arabian Sea	27,031	3,590	30,621
24	Kalinadi ..	96	Diggighat	Arabian Sea	25,600	238,210	263,810

catchment areas as they apply to the Forests in the Bombay State

Serial No.	Name of the Chief Tributaries	Total length Miles	Place of origin	Place where it joins the Main River	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
9	10	11	12	13	14	15	16
18	Ghatprabha ..	263	Western Ghats at Sundargad, Belgaum taluka	Joins Krishna river at Sangam, Bagalkot taluka, Bijapur Dist.	124,038	184,419	308,457
19	Malprabha ..	192	Kankumbi, Khanapur taluka	Kudal Sangam, Himgund taluka, Bijapur Dist.	171,509	148,474	319,983
20	Tungbhadra ..	85	In Mysore State, within the Southern Circle of this Province	Alampur (Hyderabad State)	97,027	48,513	145,540
21	Markandeya* ..	56	Near Hajgoli in the Western Ghats	Joins Ghatprabha near Gokak in Belgaum Dist.	26,560	90,240	116,800
22	Tamraparni* ..	36	Near Waghotre Western Ghats	Joins Ghatprabha near Daddi in Belgaum Dist.	20,160	51,840	72,000
1	Kala ..	46	Kondath	Dhasgaon	9,600	13,440	29,440
1	Dakhil† ..	10	Chonkal	Sarmale	17,167	883	18,050
1	Kusgaon ..	14	Kusgaon	Pandoor	17,461	362	17,823
2	Pangrad ..	18	..	..	32,548	208	32,756
1	Ghotge ..	8	Ghotge	Chunawara	26,387	..	26,387
2	Kalsuli ..	20	Kalonli	In Malwan	28,213	..	28,213
1	Kendra ..	12	Kendra K.D.	Konal	22,978	2,088	25,066
1	Nemle ..	8	Bhambarde	Talode	7,196	960	8,156
1	Pandhari ..	36	Near Anmod Supa Petha, North Kanara Dist.	Supa	..	77,430	77,430
2	Kaneri ..	36	Keloli North Kanara Dist.	Sawmagi, Haliyal taluka, N. Kanara Dist.	..	93,235	93,235
3	Tattihalla ..	28	Near Tatwani, Haliyal taluka, N. Kanara Dist.	Lalguli, Yellapur taluka, N. Kanara Dist.	..	84,405	84,405

* Chief tributaries of Ghataprabha river.
† In Sawantwadi State.

Statement showing information in respect of water supplies and

Serial No.	Name of the Chief River	Total length from source to mouth miles	Place of origin	Name of the sea into which the river flows	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
1	2	3	4	5	6	7	8
24	Kalinadi—(*contd.*)						
25	Bedti .. (also called Gangawati)	105	Someshwar Dharwar taluka	Arabian Sea	30,720	301,717	332,437
26	Aghanashini ..	60	Near Sampkhand Sirsi taluka, N. Kanara Dist.	Arabian Sea	20,480	42,240	62,720
27	Sharavati ..	About 120	Ambutirth, Mysore State	Arabian Sea	22,400	35,200	57,600
28	Venkatpur ..	32	Baswanthavi Mysore State	Arabian Sea	10,240	17,920	28,160

catchment areas as they apply to the Forests in the Bombay State

Serial No.	Name of the Chief Tributaries	Total length Miles	Place of origin	Place where it joins the Main River	Catchment area		
					Denuded of Forests Acres	Still under Forests Acres	Total Acres
9	10	11	12	13	14	15	16
4	Vaki ..	18	Landke, Karwar taluka, N. Kanara Dist.	Sulgeri, Karwar taluka, N. Kanara Dist.	..	29,725	29,725
5	Nagi ..	15	Kakti, Supa Petha, N. Kanara Dist.	Dongarwada Supa Petha	..	29,290	29,290
6	Barchi ..	12	Amshet, Supa Petha	Mavling, Haliyal taluka	..	39,245	39,245
7	Karka ..	16	Mundki Haliyal taluka	Kariyampali Haliyal taluka	..	23,780	23,780
8	Nagzari ..	8	Near Kulgi Haliyal taluka	Karda Haliyal taluka	..	14,693	14,693
1	Kaulgi ..	24	Near Sanvalli, Mungod taluka, N. Kanara Dist.	Near Bankasali Yellapur taluka, N. Kanara Dist.	..	34,635	34,635
2	Sonda ..	20	Near Baligadde Sirsi taluka, N. Kanara Dist.	Near Harigadde Yellapur taluka, N. Kanara Dist.	..	32,425	32,425
3	Handimadi ..	8	Shiveguli Hills Ankola taluka, N. Kanara Dist.	Near Honalli Ankola taluka	200	10,040	10,240
1	Benihol ..	15	Devanhalli hills Sirsi taluka	Morshet Kumta taluka	100	3,740	3,840
2	Sandolli ..	12	Yan hills Kumta taluka	Near Uppinpattan	5,120	10,240	15,360
1	Kalkatti Nalla*	13	In Kunnur hills Mysore State	Near Gersoppa village in Honawar taluka, N. Kanara Dist.	500	12,300	12,800
2	Dodmani ..	16	In Kangdi hills Kumta taluka	Near Mavinkurve Honavar taluka	6,400	12,800	19,200
1	Chitali Nalla† ..	11	Near Kake Bhatkal Petha, N. Kanara	Near Kerkol Bhatkal Petha	1,000	11,800	12,800

* Only 36 miles of the river from the mouth in the Southern Circle of this Province.
† Only 16 miles of Venkatpura are in Southern Circle.

BURMA

Before the British came into Burma teak timber was exported from Rangoon from about the middle of the 18th century. The teak was a royal tree and the whole of the big export business was done by consent of the Alompra dynasty, no one being able to fell a teak tree without a permit.

At that period Burma was practically covered with forests in which for a large part, the teak was the chief species and practically the only marketable export timber of the great mixed tropical forests. Burma's greatest wealth was in its teak timber.

The British first made acquaintance with Burma in the south after the Tenasserim and Martaban Provinces were ceded to the British by the Burmese under the treaty of Yandaboo in the year 1826. Up to then the biggest amount of teak obtained by the British Government in India and by the Admiralty at home, was obtained from the accessible teak forests of Malabar on the west coast of Madras which were mostly cut out by 1830.

Dr. Wallich, Superintendent of the Calcutta Botanic Gardens, was sent to report on the botanical features of the forests of the new Province. He reported a great wealth of teak timber and advised their working by Government. "No forest is inexhaustible" said Wallich and instanced the condition of the Malabar teak forests.

The Commissioner appointed to the charge of the new Province did not agree and gave the accessible teak forests situated on the Salween and Attaran rivers out to lessees to fell teak as they pleased, the few rules drawn up being ignored.

A score of years after the annexation the greater part of the accessible forests had been treated in a fashion similar to the Malabar area. The owners of the licences deserted their areas as soon as all accessible teak had been extracted and the forest covered teakless lands came back into Government control.

The 2nd Burmese War took place in 1852, the outcome being the annexation of the Province of Pegu. Rangoon was the capital, teak being the chief staple industry. The teak was a royal tree under the Burmese Kings and the Governor-General proclaimed all the forests Government property and the teak a monopoly, and he directed that their management should be on these lines.

The officers in charge, however, introduced the Tenassarim management. As soon as he learnt of this the Governor-General, Lord Dalhousie, laid down what became a Forest Charter. He laid down that the forests were the property of the State, i.e., the public, and that the material in them should be sold at a price the market was prepared to pay. That the system under which the timber merchants took up a block of teak forest and worked out all the teak at a great profit, paying the owner a lump sum down and an agreed price per tree or log extracted must cease.

Dr. Brandis was the man appointed to introduce the policy and was the first man to inaugurate a system by which he ascertained the volume of the exploitable teak in the blocks of forest and marked all the trees to be girdled for felling and these were the only ones the timber contractor taking the block was allowed to fell. The trees had to be girdled two years before felling, as green teak will not float and all extraction to Rangoon was by floating down the Irrawaddy and its tributaries.

Brandis introduced his famous strip surveys under which he divided the teak into four girth classes, the first class being those of 6 feet and over at Breast Height. These were the only ones marked for felling and certain safeguards were introduced. By this means unchecked overfelling ceased from this introduction by Brandis in 1856.

This system was subsequently introduced into India and soon became the rule governing all fellings in the Government Reserved Forests. Brandis had first tried to work the teak forests departmentally but soon recognized that this was far too great a task for a Government Department. He finally arranged the well-known Burma 15 year licences by which method the big timber merchants took a block of forest for 15 years, worked out all the trees marked by the Forest Department and then had their licence renewed for another block. Great opposition to this method was put up by the big timber companies and the case was carried home to the Privy Council who supported the Secretary of State for India and the Governor-General.

The 3rd Burma War and the annexation of Upper Burma might be said to have witnessed the third advance in forestry progress in Burma. The proclamation of the annexation of Upper Burma in January 1886 was made just 60 years after the annexation of Tenasserim. The new territory placed an enormous area of potential teak and other forests under the Forest Department, the staff of which was far too small to deal with the task. However, progress was made in a remarkably short time by transferring some officers from India.

Once again, and for the last time, the big timber contractors sought to get a free hand in the exploitation of the teak forests in this new Province. Once again the fight was carried to the Privy Council. But the Inspector-General of the day, Ribbentrop, who had had long experience in Burma as a forest officer, won his case : and all the more easily since it was possible to point to the Pegu Forests thirty years after Brandis had stopped unchecked fellings and compare them with the position of the cut-out Malabar Forests in 1830 and Tenasserim in 1845.

The policy was in force till the end of British rule in India with the loyal co-operation of the big timber companies. It is a pity that in other parts of our Empire the same policy was not followed, the Forest Officer remaining in charge of all areas of forest leased to timber companies.

The reservation of the Forests went steadily forward during the last thirty years of the century. Another matter, first enunciated by Brandis, but not actually put into practice by him, was to make use of the nomadic shifting cultivation habits of the Shans and Karens by getting them to sow teak seed or plant in teak plants with their (shifting) cultivation. The idea was not new : both in France and Germany the practice had been in force in the past. In Burma the term 'taungya' had been given to the method, from the Burmese word for shifting cultivation. Considerable patches of young teak poles existed at the end of the century about the country, but as no record or map had been kept they had mostly been lost to sight in the encompassing forest. In the early years of the present century the method fell into abeyance, but was revived at Tharrawaddy during the second decade of the century with very great success. This practice was adopted in the case of Sal in Bengal and spread throughout India and out to Africa and other parts of the Empire. I saw it in practice by the French forest officers in the Ivory Coast in 1934, copied from the excellent work of British officers in Nigeria. I also saw it in its early stages in Sierra Leone and the Gold Coast.

Forest administration based on sound silvicultural management and finance made great progress in Burma during the first two decades of the present century. The first World War proved the soundness of the foundation laid. Great demands were made upon Burma to supply the requirements in Mesopotamia, and several other species besides the now commonly used ones, teak and pyinkado, were utilized, some remaining on the market afterwards.

Since the first successful attempt at protecting an Indian teak forest from fire (in the Central Provinces in 1864) during the hot weather season in India had proved successful, a fire protection system had been devised for all the reserved forests in India and Burma.

Fires occurred annually : but the wholesale scale of former times had come to an end. At the beginning of the present century fire protection in the moist teak forests in Burma was called in question. It was found that a low growth of evergreen and semi-evergreen shrubs covered the forest floor, through which no teak seedlings could penetrate. Careful examination showed this to be true in both the moist teak and moist sal areas (in India). Fire protection was, therefore, given up save in the very new young crops. As an outcome, a practice termed 'early burning' was adopted, with good results.

To the trained and experienced forest officers, the test of the efficiency, thoroughness and permanency of a forest administration can be studied in one way and one way only—by the presence of working plans in the area of forest administered, the degree of intensity on which the working plans are drawn, and the manner in which they are worked. A Forest under a well-drafted working plan which has passed the scrutiny of the higher forest authority, and been sanctioned by the civil administration of the country, is as safe as man can make it. The bulk of the Government Reserves throughout the Indian peninsula are under working plans. Burma holds a high place in this important practice of the correct administration of a forest. It is understood that no serious damage to the teak forests was done during the Second World War. Teak is chiefly a timber felled for export. During the war, all teak exports ceased and the Japanese did not undertake any serious fellings in the teak areas, only cutting what they required for their military forces. In 1939 it may be said that Burma could show as fine a series of working plans for great forests from, to quote examples, the plans for South Toungoo, and Tavoy, in Tenasserim, South Pegu, Zigon and the Northern Shan States, to the Mu and Katha Forests and those of the Chindwin in the north. The work is not finished. For example, some of these working plans have been revised or re-written several times since the early days of the first real working plan (omitting the 'paper' or purely volume statistic plans of Brandis' day) of the early 'eighties'. Others are first plans, as, for example, the Mu working plan drawn up for the period 1929–30 to 1938–39.

The total area of the Government reserved forests in Burma in 1938–39 on March 31, 1939, was 20,100,221 acres.

Shifting cultivation in Burma was regulated and no area rich in teak could be felled for this purpose. As had been shown the forest tribes, Karens, Shans and so forth, help the Forest Officer in obtaining new young crops of teak.

(To be continued)

WEATHERING TRIALS ON AIRCRAFT WINGS

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INTRODUCTION

In April 1943 the Ministry of Aircraft Production, U.K., enquired whether we could co-operate in an International Scheme of tests to determine the temperature and moisture content conditions in wooden aircraft wings in service in India. In the U.S.A. tests were carried out by the Forest Products Laboratory, Madison, on Anson wings in two locations, *viz.*, Tucson and Madison. In Canada similar tests were made at Ottawa and Prince Albert by the Canadian Forest Products Laboratory. In U.K. the Forest Products Research Laboratory carried out tests with a Miles Master wing and an Oxford wing. In Australia tests were done on Anson and Mosquito wings at two locations. The Australian scheme also included some flight tests. As the determination of the conditions of temperature and moisture content which may be attained by wooden Aircraft wings operating under war time conditions in the tropics was not only necessary and useful for the intelligent design of aircraft suitable for the tropics but also be valuable for designing specification tests for aircraft materials and for the development of adhesives, preservative treatments and surface finishes the work was taken up. The results obtained in the investigation form the subject of this publication.

EXPERIMENTAL

Locations of tests and mainplanes employed.—These experiments were carried out at two stations, *viz.*, Dehra Dun (30·20 N. and 78·6 E.) and Cochin (9·58 N. and 76·17 E.). Dehra Dun is ideally suited for such tests as it has a very dry hot summer followed by a wet and warm monsoon period and a cold and dry winter, the humidity fluctuating anywhere from 10% to 100% during the year. On the other hand Cochin being on the sea coast, the climate is fairly warm and humid throughout the year.

At Dehra Dun the following components were installed for tests : Master mainplane port (No. PP123227) on rotating turn-table ; Master mainplane starboard (No. PP140080), leading edge facing south ; Oxford port (No. 1029001) leading edge facing south ; Oxford starboard (No. 1029002) leading edge facing north ; Anson port (No. RY/LW/14307) leading edge facing south ; Mosquito starboard (No. 778) facing south-east ; Mosquito port facing north, Horsa tail plane port (No. TP1127) facing south ; Horsa tail plane starboard (No. TP 1138) facing south ; and Horsa fin (No. 577) facing south. Later a synthetic resin bonded Horsa tail plane, part of a Horsa mainplane, section of a Mosquito fuselage and a section of a Hornet wing were installed. At Cochin the following were installed ; Oxford mainplane (Port and Starboard) and Anson mainplane (Port and Starboard).

The Aerofoils were fixed (on trestles) at normal height, angle of incidence and dihedral assumed when the aircraft is picketed, i.e., tail wheel on the ground. The general lay-out at Dehra Dun can be seen from Figs. 1, 2 and 3.

The conditions of the mainplanes prior to installation were as follows :—

Master Mainplanes.—These were received in good condition and no repairs were necessary. The mainplanes were fitted with access doors for the insertion of thermocouples and timber specimens.

The root ends were covered with fabric to simulate natural conditions and the planes were doped (1 coat) in accordance with the camouflage scheme for single engined aircraft.

The Anson Mainplane.—Was received extensively damaged, 6 feet of the mainplane tip missing on the starboard side. As owing to lack of proper materials we were unable to reconstruct this mainplane in its entirety, the starboard mainplane was sawn off at the nearest rib and the end covered with fabric. With the port mainplane the wing tip sweep was damaged, 4 ribs were missing from the leading edge and the plywood skin was damaged in 23 panels. It was repaired, re-camouflaged, access doors fitted and mounted on trestles. The mainplane was received without the trailing edge.

The Mosquito Mainplanes were also received in a severely damaged condition. Extensive repairs were carried out on both port and starboard mainplanes, access holes cut and fitted with doors and the mainplanes re-camouflaged.

The Oxford Mainplanes were received in good condition, no repairs being necessary. They were re-camouflaged, access holes cut and fitted with doors (*vide* Fig. 3).

The Horsa Tail Planes and Fin were also received in good condition, no repairs being necessary. Access doors were fitted and the appropriate camouflage scheme adopted.

All access doors were fitted with felt washers to prevent loss or ingress of heat and moisture.

At Cochin the mainplanes were installed as received in the harbour area on a concrete platform which was in existance (*vide* Fig. 4).

Measurement of temperature.—For the measurement of temperature copper-constantan thermocouples (32 S.W.G.) were employed. These were fixed on the surfaces at the locations required with the help of aircraft dope and small pieces of madopallam fabric, care being taken that the wires from the junction were on an isothermal plane for at least 2 ft. Where temperatures of air inside the wings were required the thermocouples were fixed in small wooden stands at the appropriate places. For measuring the thermal e.m.f. developed a Lindeck-Rothe compensation circuit was employed (*vide* Figs. 5, 5a and 6). A mirror galvanometer was used as the null instrument, the thermocouples being connected to the arrangement by an 11 point multiple switch. The galvanometer and the optical system were located in a box and installed under the wing (*vide* Fig. 3). The accuracy of the measurement varied with the galvanometer and ammeter employed. In most of the cases as galvanometers with an accuracy of 10^{-9} amp. and milliammeters of high accuracy were employed, temperatures could be read to an accuracy of 0·1°C and more. In the adverse cases the accuracy was 0·3°C. The calibration curves are given in Fig. 7.

Shade temperatures were measured by both thermocouples and mercury in glass thermometers hung in the shade under the wings (*vide* Fig. 3). For measuring black body temperatures thermometers inserted in a blackened round bottomed flask or a thermocouple inserted in a small metal (blackened) sphere were used. The black body temperature for a few days are given in Fig. 8.

Humidity measurements.—For the direct measurement of humidity inside the wings, in one or two locations wet and dry thermocouples were installed. As the measurements had to be done in still air, thin copper-constantan (40 S.W.G.) thermocouples were employed for the purpose. Wet filter paper was used as the covering for the wet thermocouples. The water used for wetting the thermocouples was placed in a sealed container in the same location. The humidity of the air outside was measured both by wet and dry bulb mercury in glass thermometers and thermocouples.

Rainfall.—Rainfall was recorded in a gauge installed in the yard. The data for the period are given in Fig. 9.

Moisture content.—For following the changes in moisture content within the wings, veneers, solid wood pieces and grids were employed as follows (Fig. 10).

Veneers.—Usually *Zanthoxylum rhetsa* veneers $1/64'' \times 2'' \times 6\frac{1}{4}''$ were employed. Sometimes mango (*Mangifera indica*) veneers 1/32″ were also employed.

Solid wood pieces.—Spruce specimens ($1\frac{1}{2}'' \times 1\frac{1}{2}'' \times 11''$) were used.

Grids.—These were of spruce comprising five pieces $10'' \times \frac{3}{8}'' \times \frac{3}{8}''$ spaced $\frac{3}{8}''$ apart and secured by $\frac{3}{8}''$ plywood strips across each set of ends.

Tin containers with tight fitting lids were used for transporting the specimens from the wings to the balance and back, in order to avoid changes in moisture content during transport.

The specimens were placed at bottom, mid-height and on the top (very near the plywood skin) in the wings. At the bottom they were placed on the plywood surface. At mid-height they were kept on wooden stands. At top the veneer specimens were held by wooden clips.

With the veneer specimens sets of three were employed and each specimen was not weighed more than once in the day.

For weighing the veneer specimens a chemical balance was used and weights were recorded to the 3rd place of decimals. The spruce specimens and grids were weighed to the 2nd place of decimals.

Location of thermocouples and Moisture specimens.—Observations of temperature and moisture content were made at locations as shown in Figs. 11, 12, 13, 14. In the Anson, locations were similar to that given in the Madison plan. In the Oxford it was similar to that adopted at Princes Risborough. In the other wings locations were decided by us.

The departure from other places were : (1) Direct measurement of humidity in one or two locations, and (2) placing of veneer specimens at the bottom, mid-height and top in one or two locations.

Schedule of observations.—At Dehra Dun the following schedule of observations was adopted. During the hot dry weather, temperature measurements were taken every hour from 0700 hours to about 1800 hours excepting on Sundays. Moisture content weighings (veneers) were done thrice daily, at 0730 hours, 1130 hours, and 1530 hours. In the case of the spruce specimens and grids they were weighed once a week at 1130 hours. During the monsoon period the same procedure was followed excepting that on very rainy days no readings were taken. During Winter the full schedule was followed on Thursdays and on other week days readings were taken only at 1200 hours.

At Cochin the observations could not be as exhaustive and extensive as in Dehra Dun. They were confined to three periods as follows :—

Summer of 1945 (from 25–5–1945 to 16–6–1945) when the Oxford mainplanes were installed.

Winter of 1945 (from 13–9–1945 to 17–11–1945) when the Anson mainplanes were installed.

Summer of 1946 (from 17–4–1946 to 6–5–1946) and finally in1947 when observations on the condition of the wings were made.

Temperature measurements were taken mostly between 1000 hours and 1600 hours some readings were also taken throughout the night on a few days. Moisture content weighing

of veneers were taken thrice daily and in the case of spruce specimens and grids they were taken once a week.

RESULTS

Temperature.—Some typical results of temperature measurements are represented in Figs. 15 to 32. From these figures the variation of temperature as affected by types of wings, location, aspect, season and Geographical position of the experimental station, etc., can be seen. Higher temperatures were recorded at Dehra Dun than at Cochin. During summer, temperatures of over 75°C on the top skin were recorded. The maximum temperatures were usually attained between 1200 and 1600 hours during the day. The maximum temperatures went up to 90° C and those recorded at Dehra Dun were :—

Anson port facing south 88·2°C (24th May 1945) and 90·5°C (9th July 1945) ;

Master starboard facing south 86° C (22nd August 1945) and port facing south 85° C (4th July 1945) ;

Oxford starboard facing north 84°C (25th May 1945) and port facing south 82°C (24th May 1945) and

Mosquito starboard facing south-east, 77·3°C (30th June 1945).

At Cochin the highest temperatures were as follows :

74°C for Oxford port facing south (1–10–1945), 75°C for Anson starboard facing south (1–10–1945).

It is interesting to record that the highest temperatures were recorded soon after the outbreak of the rains, suggesting thereby that but for the dust in the atmosphere higher temperatures might have been recorded in May or early in June. Knight and Doman (M.A.P., S. and T. No. 8/44–PP 15.RIS 8, 1943) calculate 90°C as the possible limit to be reached in India which agrees with the values observed.

Lowest temperatures were recorded in the mornings in January. These were apparently caused by the evaporation of frost. Here again, the Anson recorded the lowest temperature of about—8°C, then the Oxford. In the other wings temperatures lower than 0°C were not noticed. In Table I are recorded the number of hours when temperature in different locations in the wings was above 50°C, 60°C and 70°C.

TABLE I

Numbers of hours when temperature in wings was above 50°, 60° and 70° each month
(DEHRA DUN)

Wing	Location	Position	Period of observation	Above 50°	Above 60°	Above 70°
1	2	3	4	5	6	7
				h. m.	h. m.	h. m.
Mosquito Mainplane Starboard	Centre mainplane	T.S.	3 days in May 1945	19 00	6 50	0
		T.S.i		16 40	0	0
		Mdht.		11 50	0	0
		B.S.		11 40	0	0

(*contd.*)

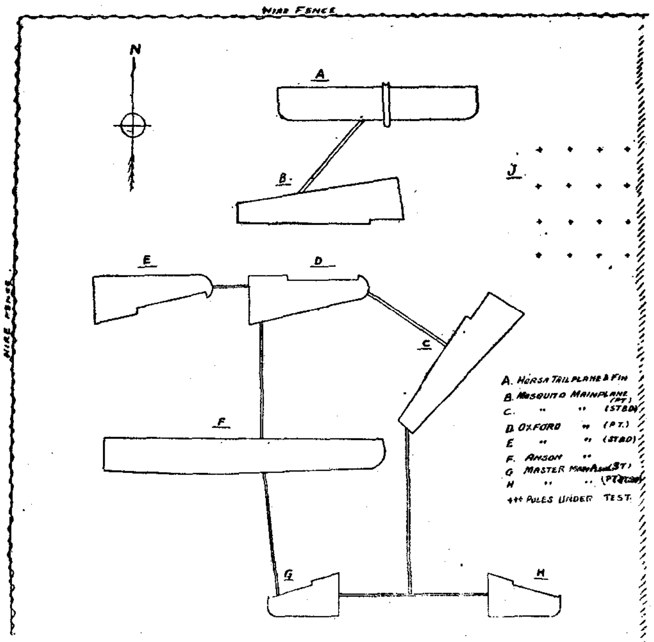


FIG. 1.—Lay-out diagram of Aerofoils at Dehra Dun.

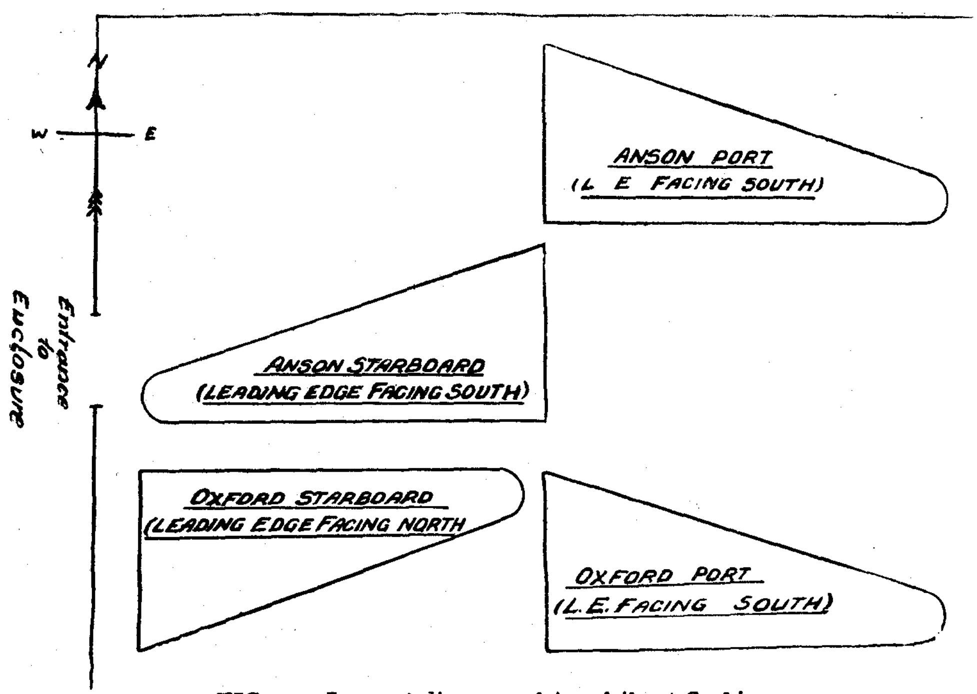
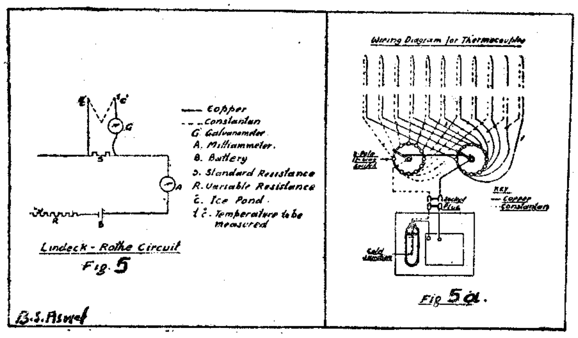


FIG. 4.—Lay-out diagram of Aerofoils at Cochin.



FIGS. 5 and 5a.—Lindeck-Rothe circuit and wiring diagram of thermocouples.

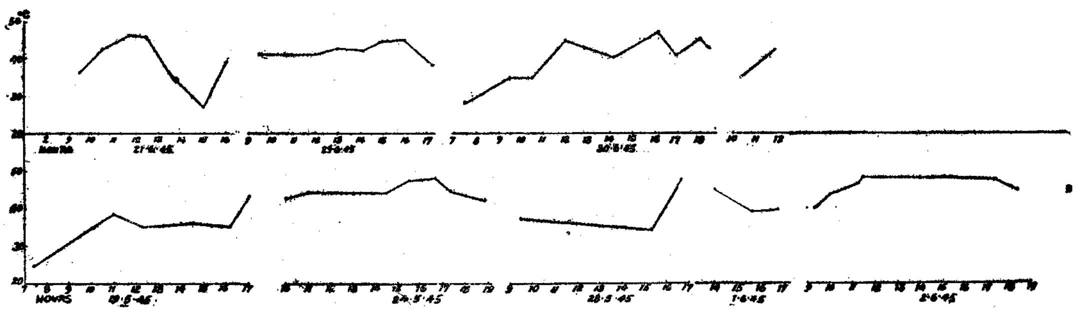


FIG. 8.—Black body temperature.

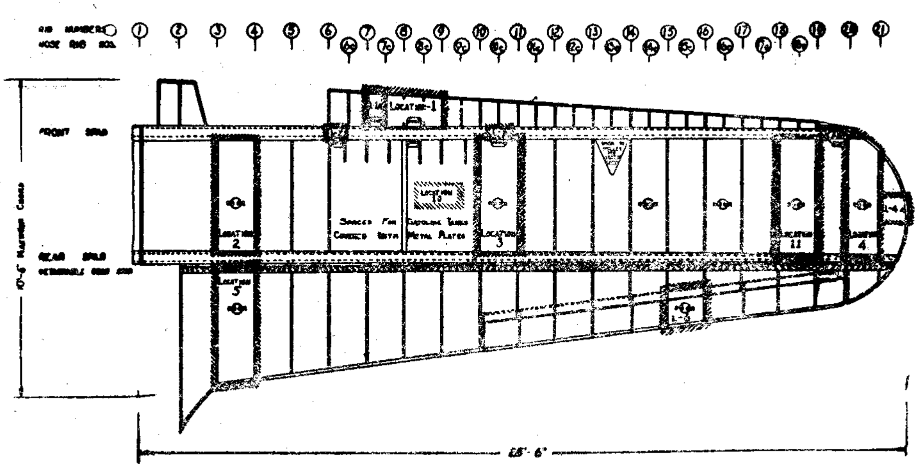


Figure — Plan of the Anson wings with hatched outlines around the locations within the wings at which observations of temperature or moisture content were made

FIG. 11.—Test locations in Anson wing.

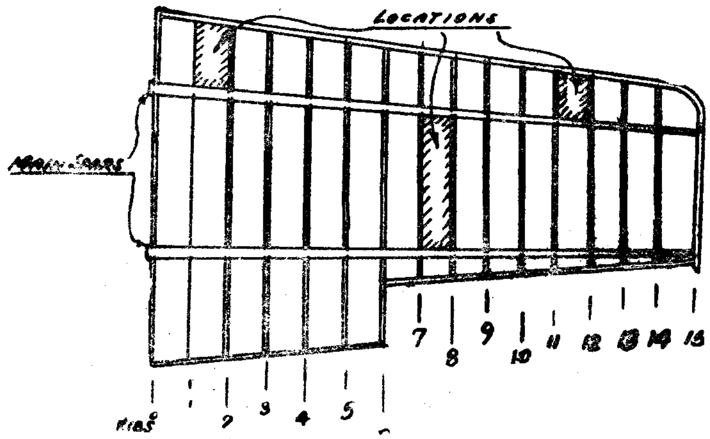


FIG. 12.—Test locations in Master wing.

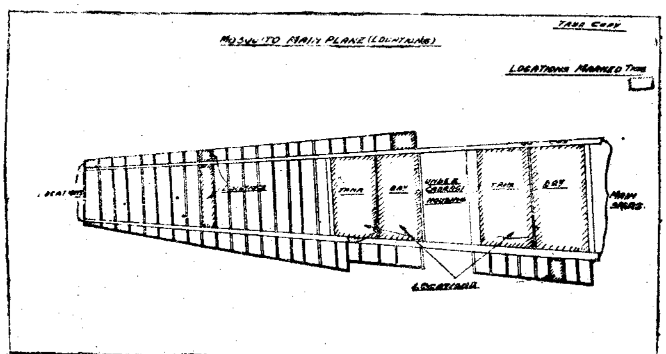


FIG. 13.—Test locations in Mosquito wing.

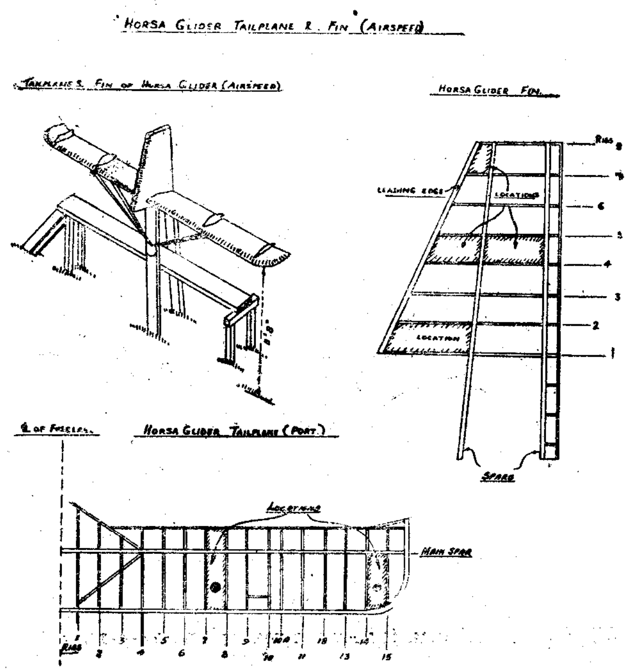


FIG. 14.—Test locations in Horsa tailplane.

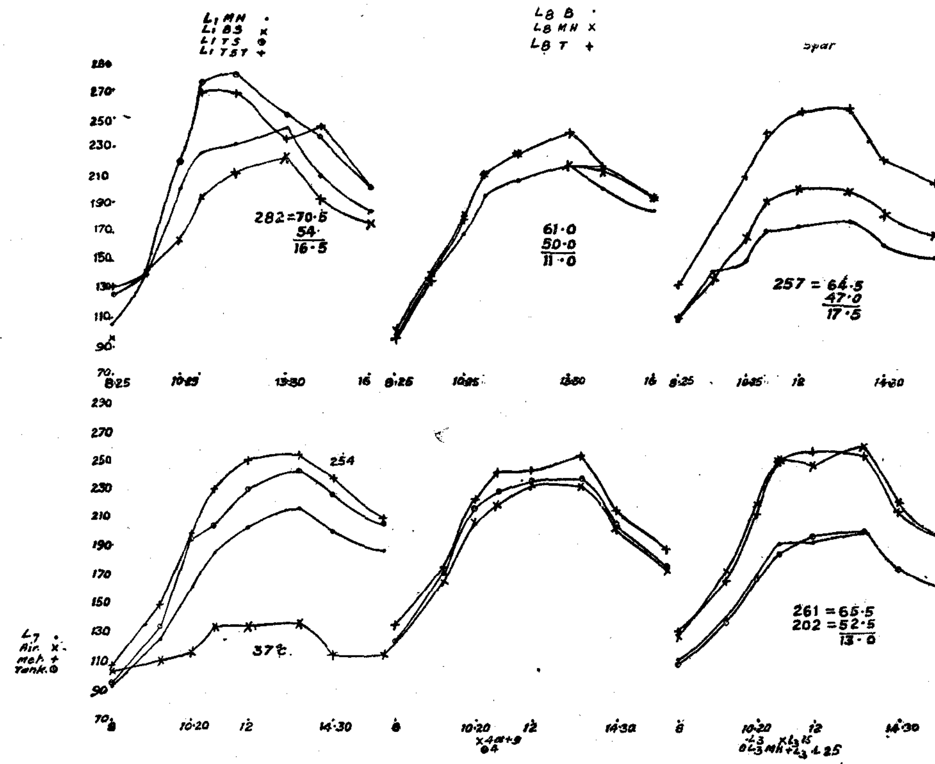


FIG. 15.—Temperature data for Anson mainplane 16-5-1945.

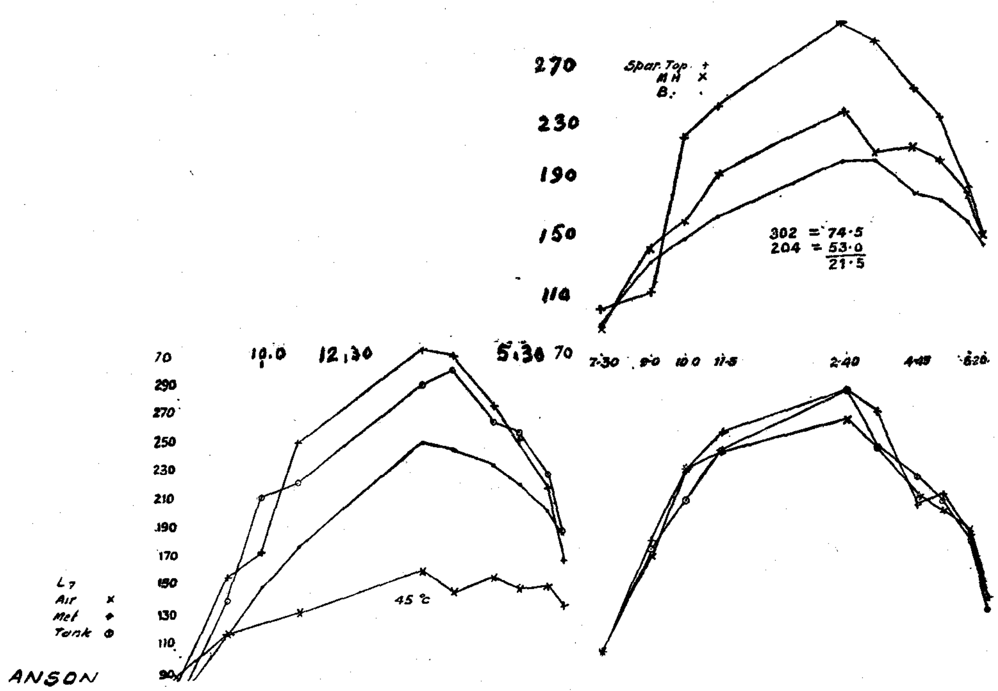


FIG. 16.—Temperature data for Anson mainplane 24-5-1945.

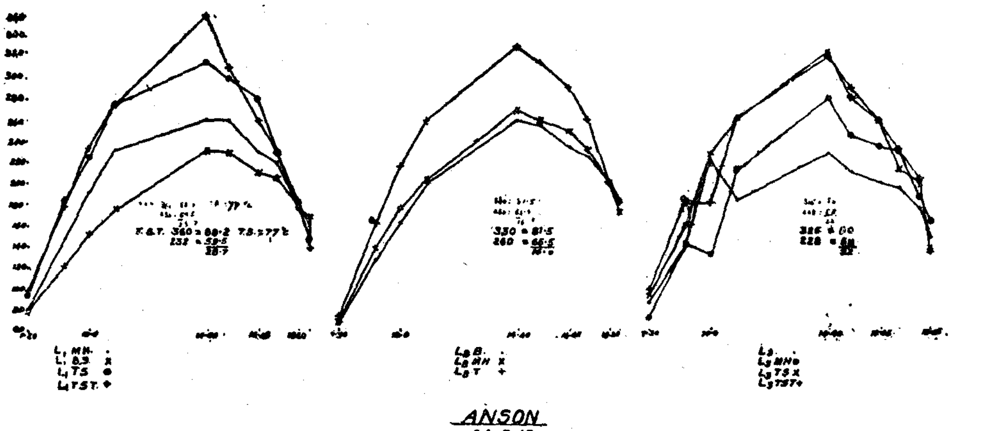


FIG. 17.—Temperature data for Anson mainplane 24-5-1945.

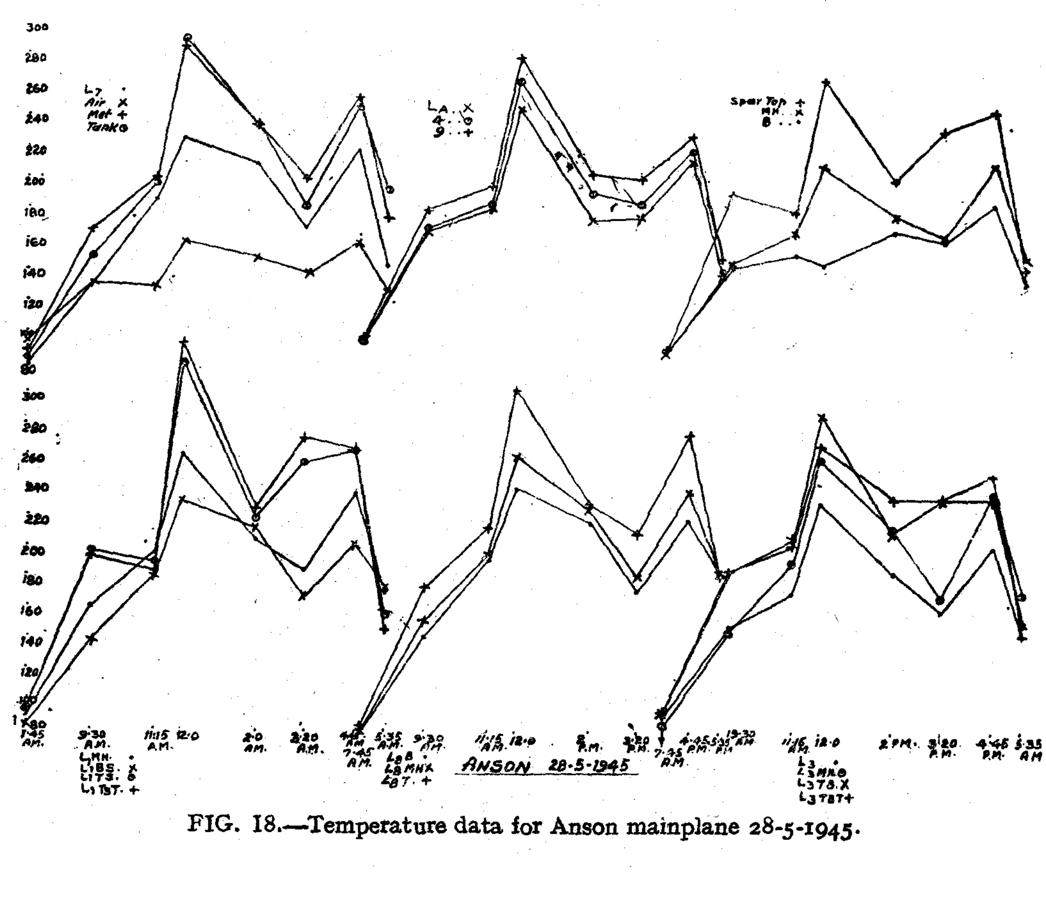


FIG. 18.—Temperature data for Anson mainplane 28-5-1945.

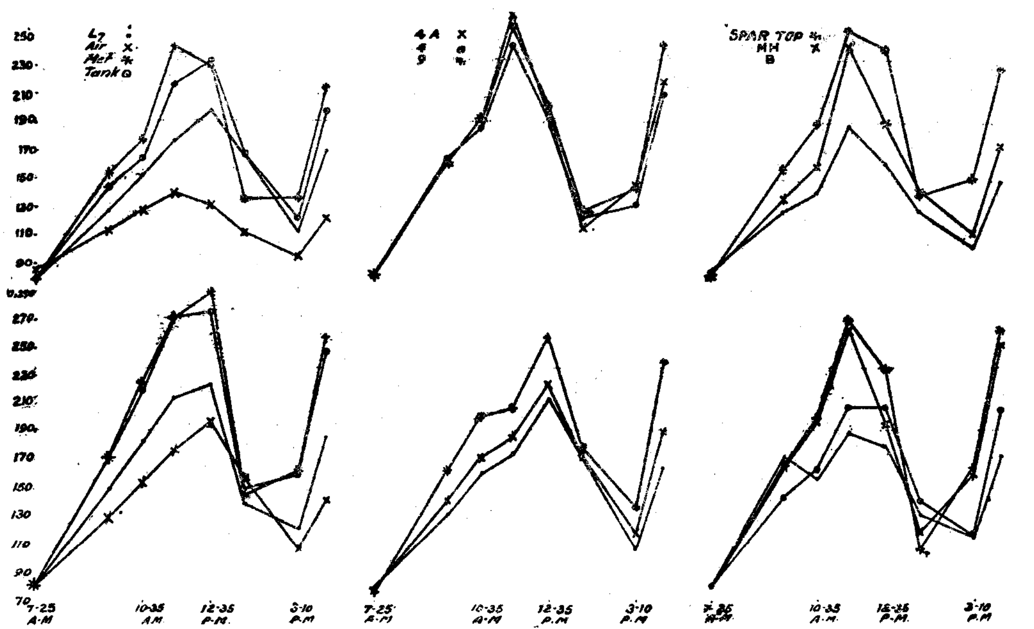


FIG. 19.—Temperature data for Anson mainplane 21-6-1945.

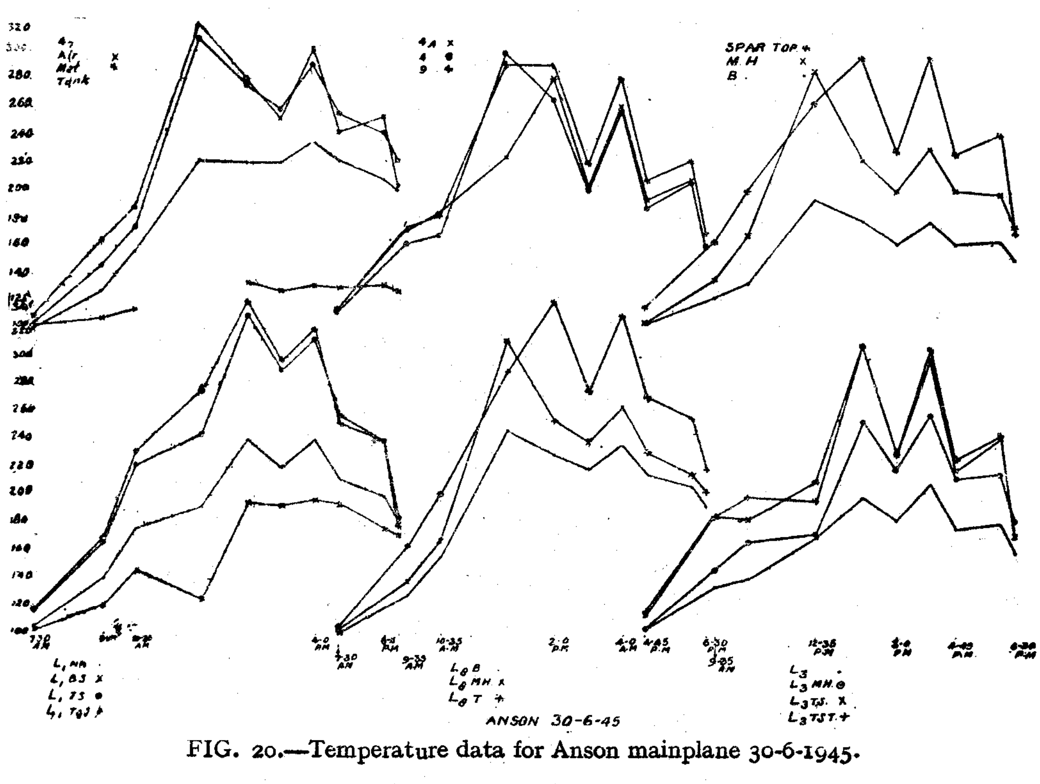


FIG. 20.—Temperature data for Anson mainplane 30-6-1945.

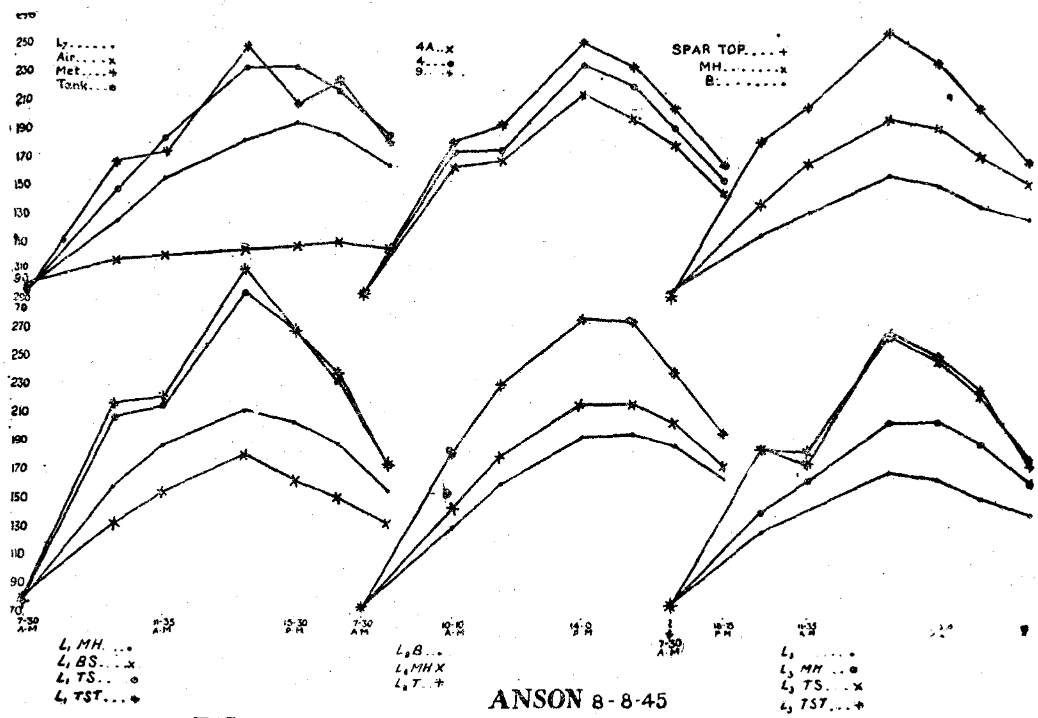


FIG. 21.—Temperature data for Anson mainplane 8-8-1945.

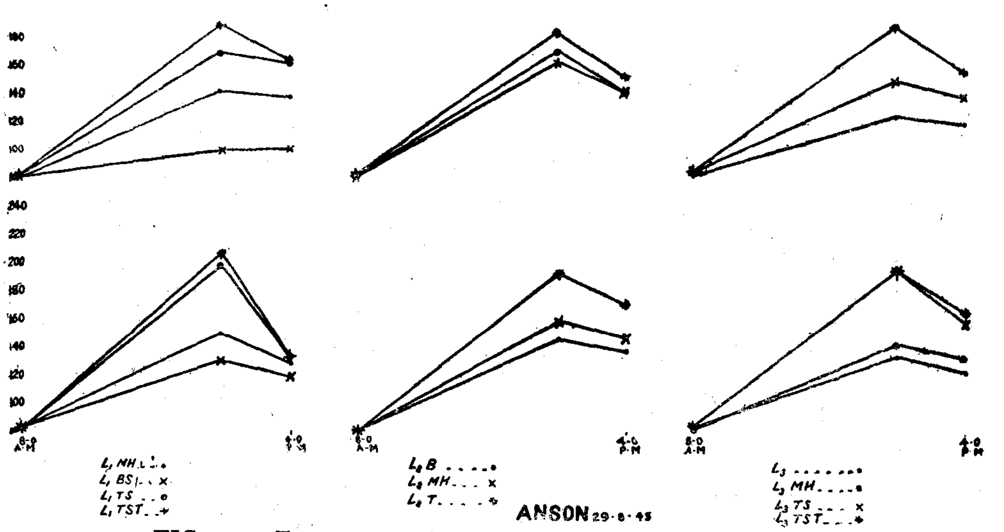


FIG. 22.—Temperature data for Anson mainplane 29-8-1945.

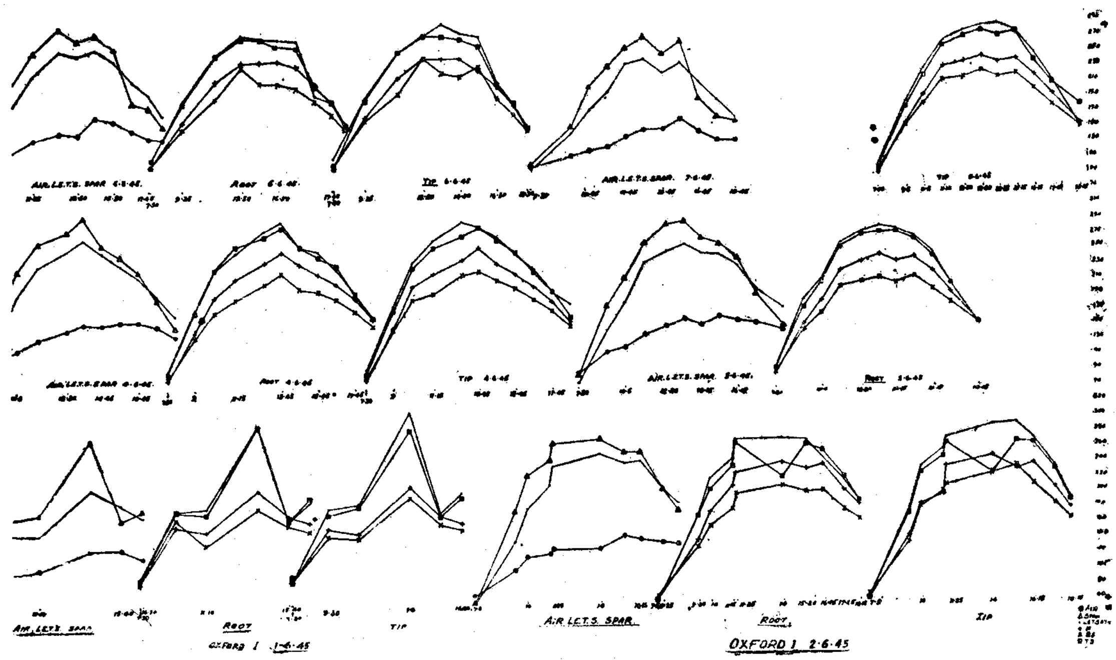


FIG. 27.—Temperature data for Oxford mainplane port 1-6-1945 to 7-6-1945.

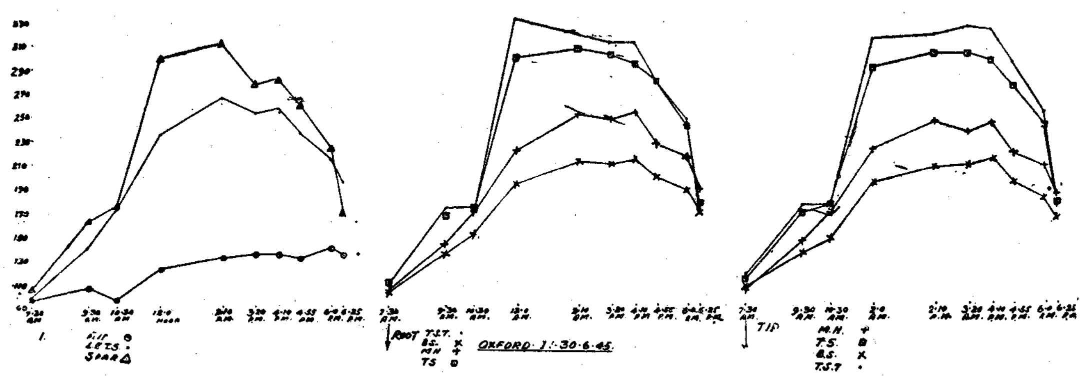


FIG. 28.—Temperature data for Oxford mainplane port 30-6-1945.

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°	Above 60°	Above 70°
1	2	3	4	5	6	7
				h. m.	h. m.	h. m.
Mosquito Mainplane Starboard	Centre section	T.S.	3 days in May 1945	20 30	10 00	0
		T.S.i		17 50	4 20	0
		Mdht.		6 40	0	0
		B.S.		4 50	0	0
	Leading edge centre	T.S.T.		20 50	14 50	0
		T.S.		20 40	14 20	0
		Mdht.		17 30	1 30	0
		B.S.		10 40	0	0
	Leading edge tip	T.S.T.		18 40	5 00	0
		T.S.		18 00	4 30	0
		B.S.		0 30	0	0
	Leading edge carriage	Mdht.		14 10	0	0
	Spar			20 40	15 00	0
	Centre mainplane	T.S.	23 days in June 1945	126 30	61 30	3 00
		T.S.i		105 00	19 50	0
		Mdht.		75 30	0	0
		B.S.		74 30	0	0
	Centre section	T.S.		141 25	80 50	9 30
		T.S.i		118 10	45 20	0
		Mdht.		62 40	0	0
		B.S.		53 10	0	0
	Leading edge centre	T.S.T.		153 10	93 10	32 20
		T.S.		149 20	89 00	24 30
		Mdht.		115 20	35 30	3 50
		B.S.		61 10	0	0
	Leading edge tip	T.S.T.		129 50	41 30	1 50
		T.S.		128 40	40 30	0
		B.S.		21 40	0	0

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°	Above 60°	Above 70°
1	2	3	4	5	6	7
				h. m.	h. m.	h. m.
Mosquito Mainplane Starboard	Leading edge carriage	Mdht.	23 days in June 1945	89 30	3 00	0
	Spar			140 50	75 20	15 10
	Centre mainplane	T.S.	24 days in July 1945	47 20	14 40	0 30
		T.S.i		33 00	1 10	0
		Mdht.		10 50	0	0
		B.S.		7 10	0	0
	Centre section	T.S.		61 40	28 00	6 40
		T.S.i		43 20	9 30	0 50
		Mdht.		3 30	0	0
		B.S.		3 10	0	0
	L.E. centre	T.S.T.		52 50	24 50	9 50
		T.S.		51 10	22 30	9 00
		Mdht.		34 40	4 50	0
		B.S.		2 00	0	0
	L.E. tip	T.S.T.		40 00	20 40	2 40
		T.S.		39 30	19 30	1 40
		B.S.		2 10	0	0
	L.E. carriage	Mdht.		8 40	0	0
	Spar			58 30	25 00	4 30
	Centre mainplane	T.S.	22 days in Aug. 1945	49 50	9 30	0
		T.S.i		31 20	2 20	0
		Mdht.		4 40	0	0
		B.S.		2 20	0	0
	Centre section	T.S.		59 40	24 40	0 30
		T.S.i		46 10	12 00	0
		Mdht.		3 40	0	0
		B.S.		0	0	0

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Mosquito Mainplane Starboard	L.E. centre	T.S.T.	22 days in Aug. 1945	70	10	39	40	6	40
		T.S.		65	00	33	40	5	20
		Mdht.		38	20	0	10	0	
		B.S.		2	10	0		0	
	L.E. tip	T.S.T.		54	20	27	00	1	20
		T.S.		56	40	23	20	0	40
		B.S.		4	20	0		0	
	L.E. carriage	Mdht.		11	40	0		0	
	Spar			59	50	27	20	0	
	Centre mainplane	T.S.	22 days in Sept. 1945	40	30	0	20	0	
		T.S.i		12	00	0		0	
		Mdht.		0	40	0		0	
		B.S.		0		0		0	
	Centre section	T.S.		49	30	17	40	0	
		T.S.i		26	30	0	10	0	
		Mdht.		0		0		0	
		B.S.		0		0		0	
	L.E. centre	T.S.T.		56	50	26	10	0	10
		T.S.		56	10	19	40	0	
		Mdht.		25	40	0		0	
		B.S.		0		0		0	
	L.E. tip	T.S.T.		40	30	16	0	0	
		T.S.		39	30	14	0	0	
		B.S.		2	30	0		0	
	L.E. carriage	Mdht.		0		0		0	
	Spar			48	10	9	50	0	
	Centre mainplane	T.S.	23 days in Oct. 1945	9	10	0		0	
		T.S.i		0		0		0	

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Mosquito Mainplane Starboard.	Centre mainplane	Mdht.	23 days in Oct. 1945	0		0		0	
		B.S.		0		0		0	
	Centre section	T.S.		29	40	4	50	0	
		T.S.i		0	10	0		0	
		Mdht.		0		0		0	
		B.S.		0		0		0	
	L.E. centre	T.S.T.		41	20	13	40	0	
		T.S.		40	30	7	10	0	
		Mdht.		12	20	0		0	
		B.S.		0		0		0	
	L.E. tip	T.S.T.		31	30	0		0	
		T.S.		27	30	0		0	
		B.S.		0		0		0	
	L.E. carriage	Mdht.		0		0		0	
	Spar			27	50	0		0	
Master Mainplane Port	Tip end	Spar	14 days in June 1945	63	10	29	10	5	00
		T.S.T.		65	00	41	20	14	30
		T.S.		65	10	42	20	13	30
		B.S.		24	30	1	00	0	
	Centre section	T.S.		62	30	32	20	2	20
		Mdht.		51	00	10	00	0	
		B.S.		10	50	0		0	
	Root end	T.S.		65	00	35	20	4	40
		Mdht.		11	30	0		0	
		B.S.		10	30	0		0	
	Tip end	Spar	24 days in July 1945	53	55	22	30	5	20
		T.S.T.		67	30	38	40	18	30
		T.S.		60	15	38	50	15	30

(*contd.*)

FIG. 2.—General assembly of wings.

FIG. 3.—Oxford wing.

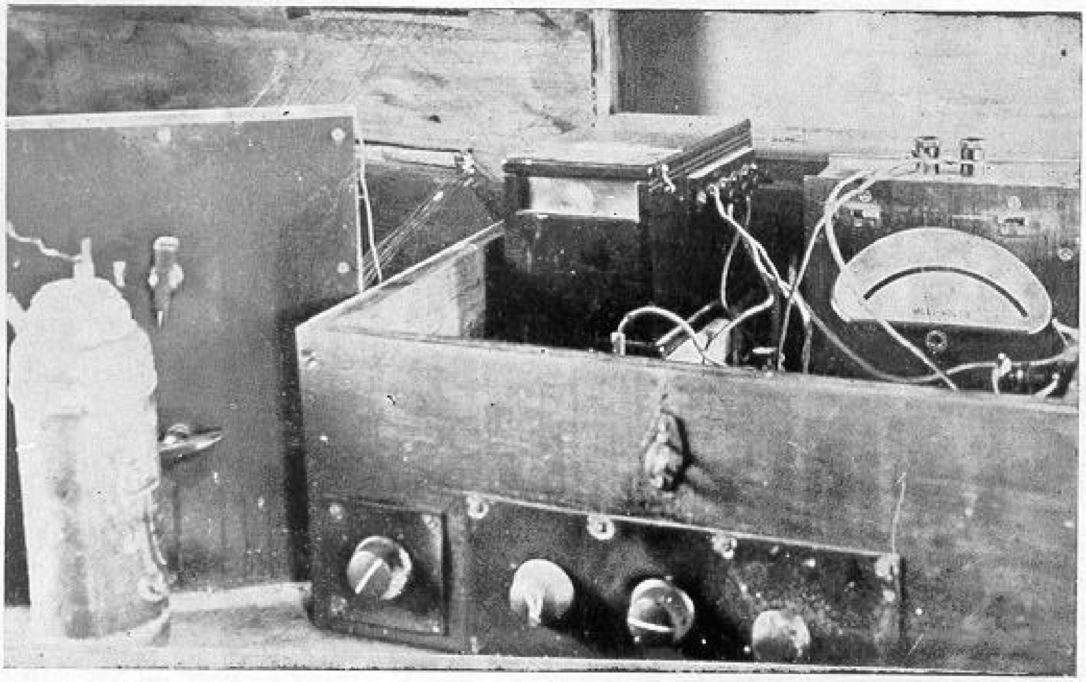


FIG. 6.—Measuring equipment.

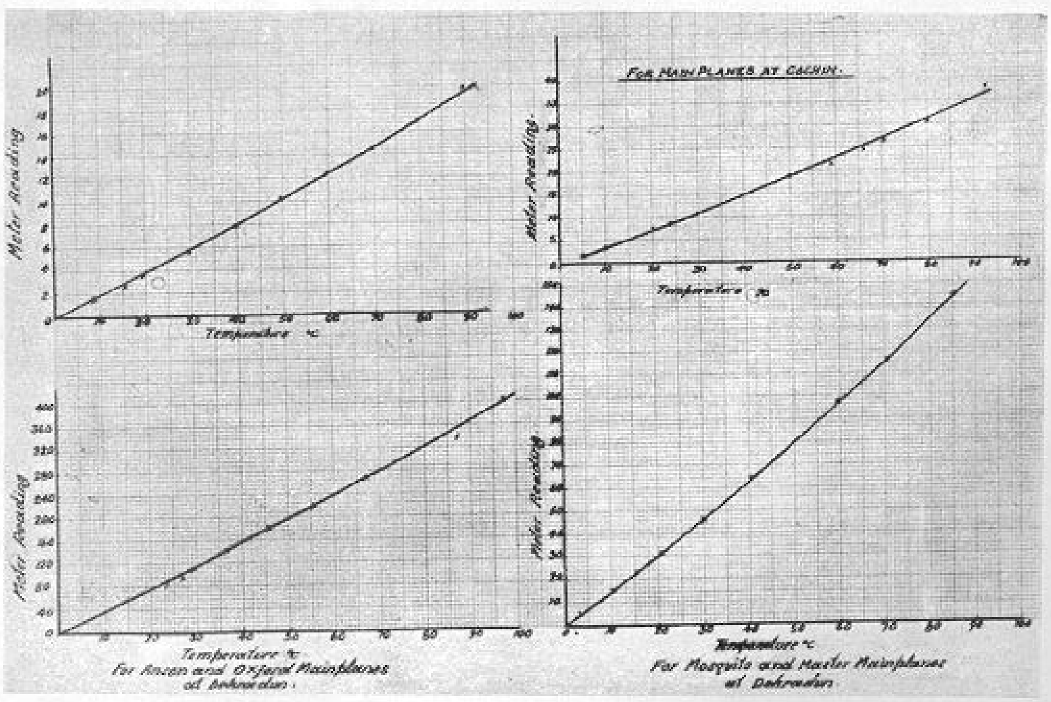


FIG. 7.—Calibration curves.

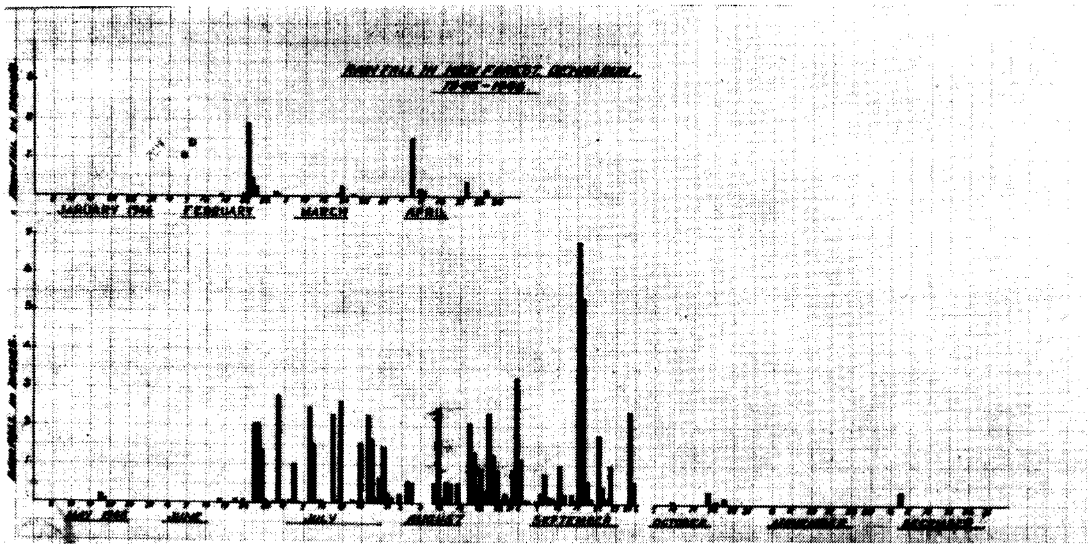


FIG. 9.—Rainfall at New Forest, Dehra Dun, 1945–46.

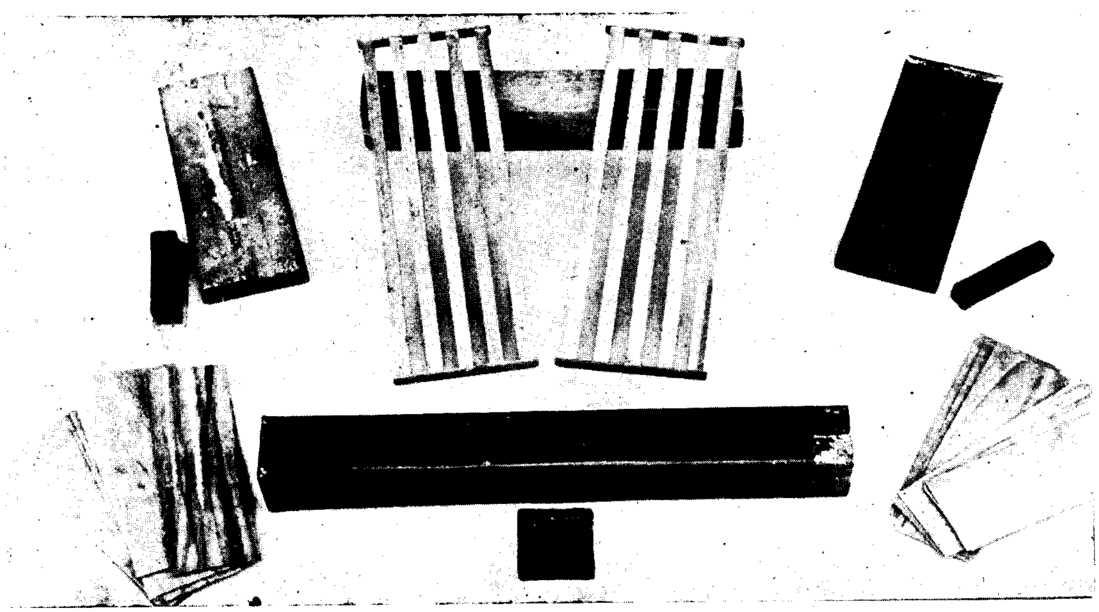


FIG. 10.—Moisture measuring equipment.

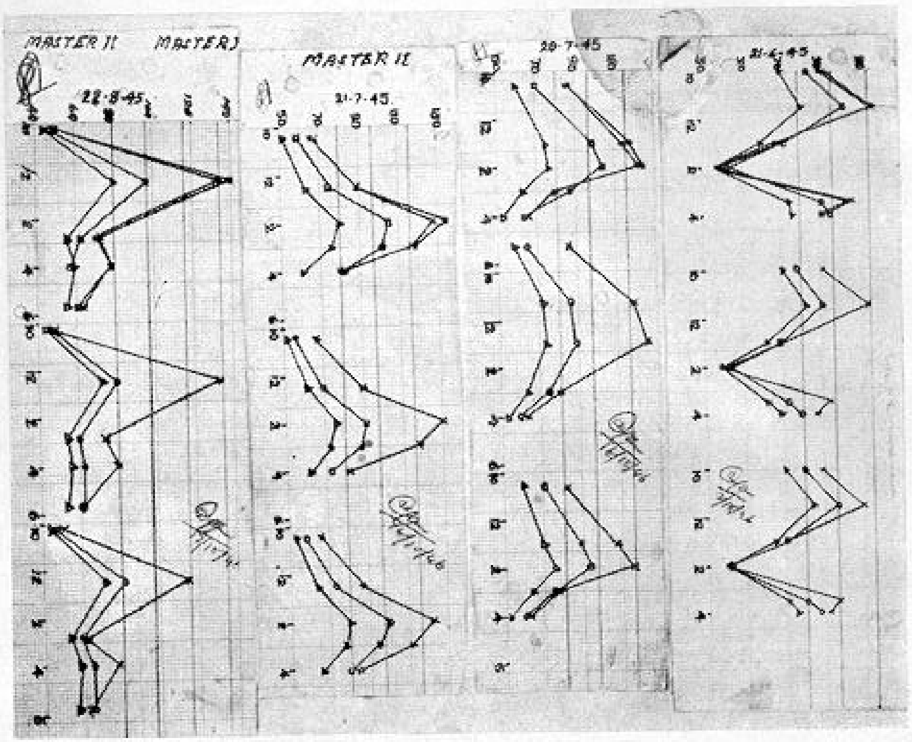


FIG. 23.—Temperature data for Master Mainplane Starboard 21-6-1945, 20-7-1945, 21-7-1945, 22-8-1945.

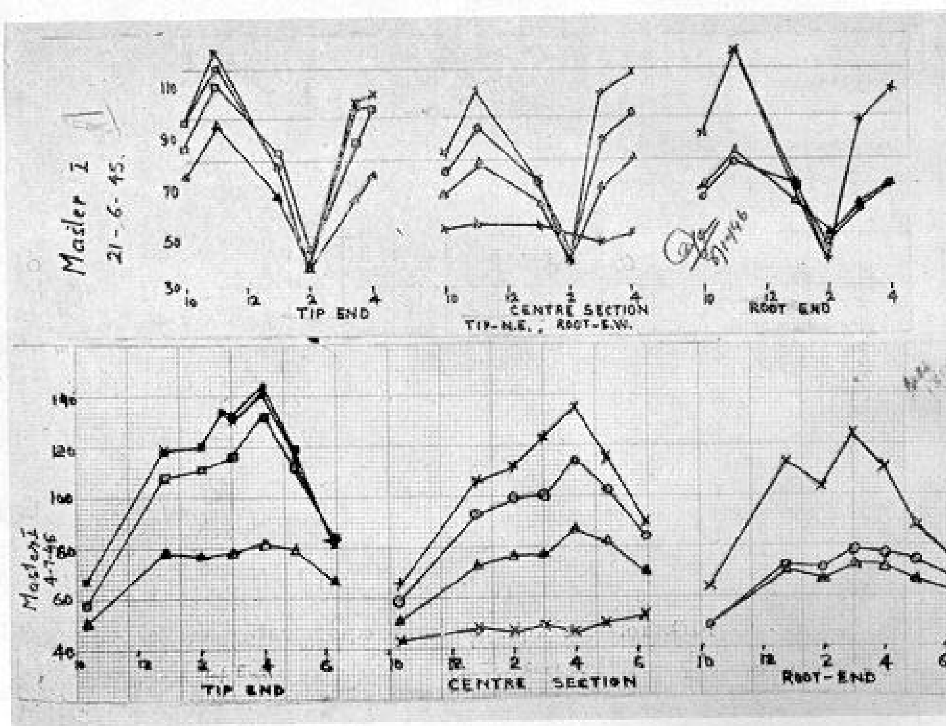


FIG. 24.—Temperature data for Master Mainplane Port 21-6-1945, 4-7-1945.

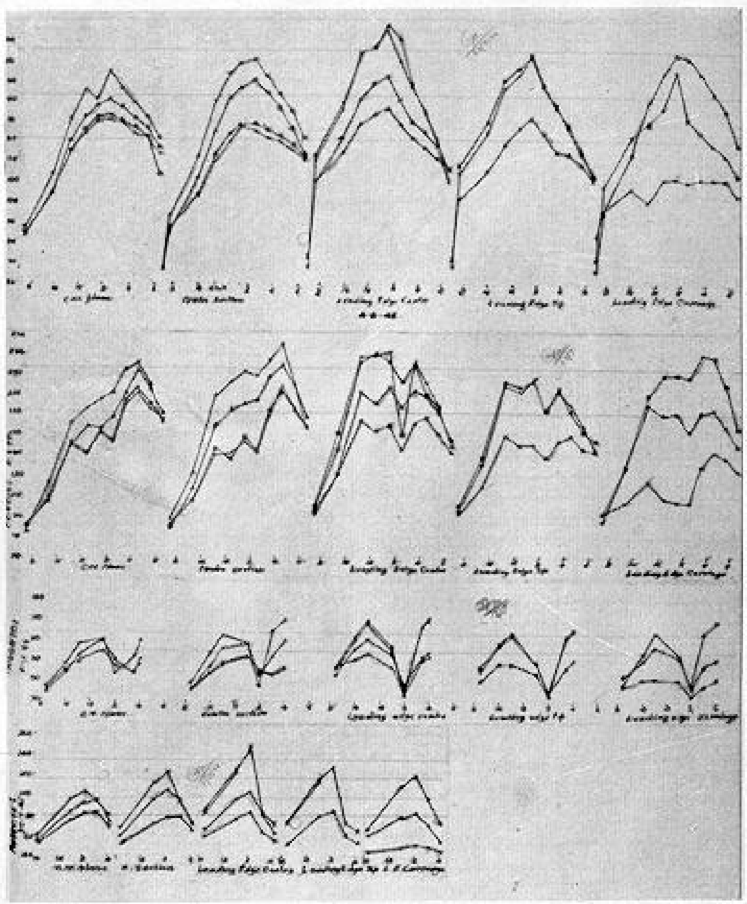


FIG. 25.—Temperature data for Mosquito Mainplane Starboard 4-6-1945, 6-6-1945, 21-6-1945, 20-7-1945.

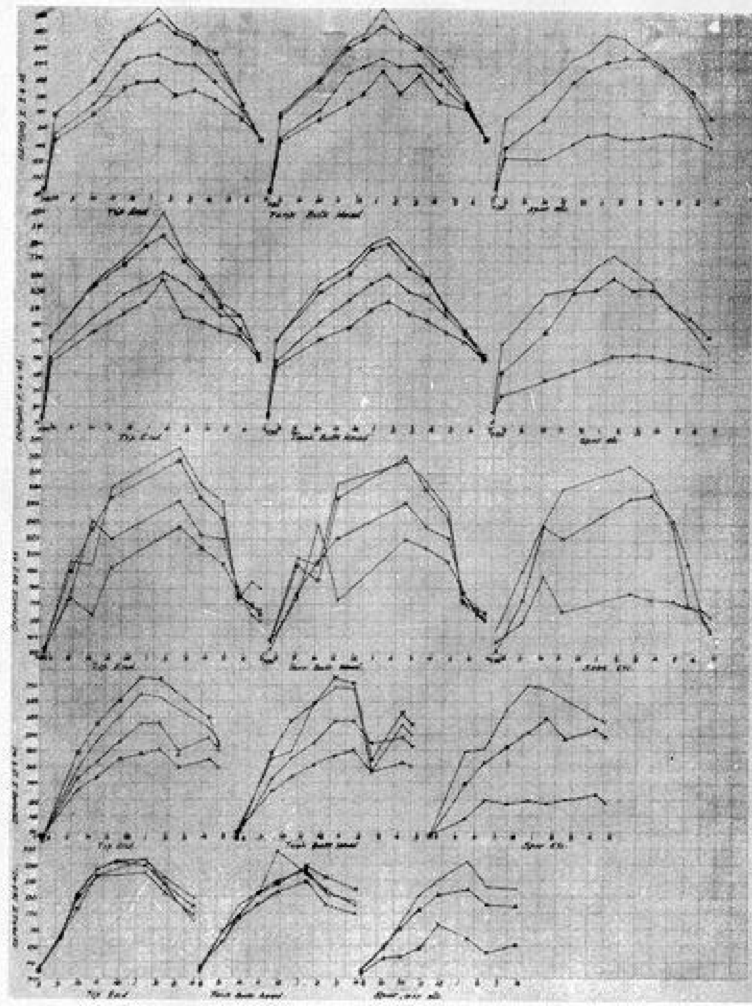


FIG. 26.—Temperature data for Oxford Mainplane Starboard 16-5-1945, 19-5-1945, 24-5-1945, 4-6-1945, 5-6-1945.

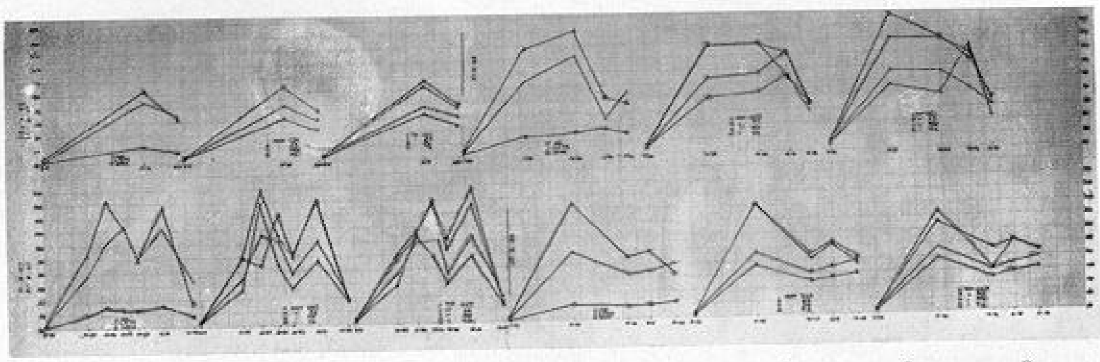


FIG. 29.—Temperature data for Oxford Mainplane Port 21-8-1945, 22-8-1945, 29-8-1945, 31-8-1945.

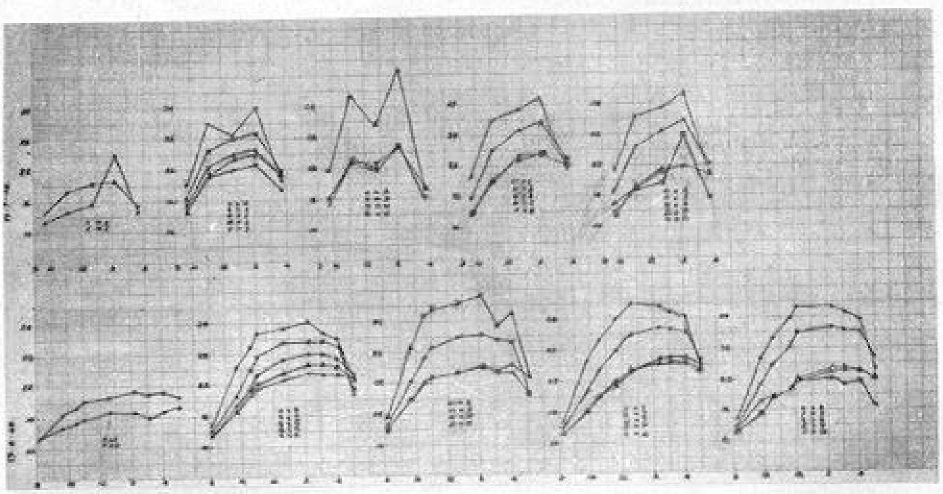


FIG. 31.—Temperature data for Horsa Tailplane 29-6-1945, 19-7-1945.

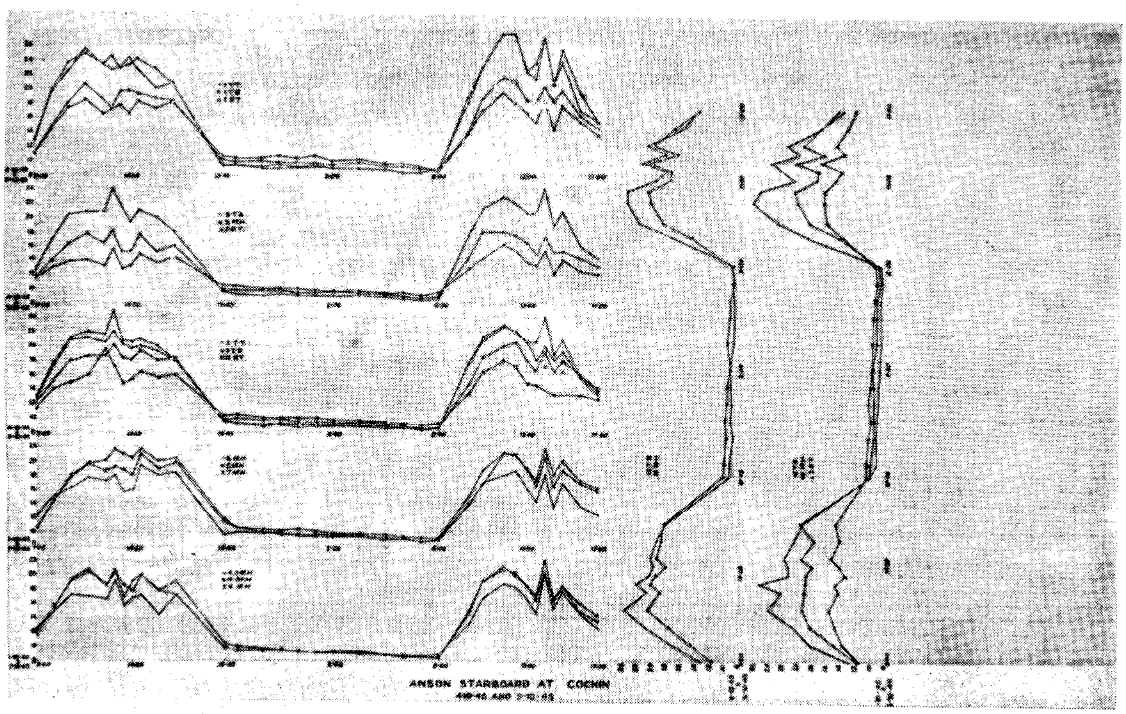


FIG. 32.—Temperature data for Anson Mainplane Starboard at Cochin 4-10-1945 and 5-10-1945.

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°	Above 60°	Above 70°
1	2	3	4	5	6	7
				h. m.	h. m.	h. m.
Master Mainplane Port	Tip end	B.S.	24 days in July 1945	5 10	0	0
	Centre section	T.S.		53 20	23 00	4 20
		Mdht.		34 05	4 40	0
		B.S.		2 00	0	0
	Root	T.S.		55 50	28 00	8 20
		Mdht.		1 20	0	0
		B.S.		0	0	0
	Tip end	Spar	22 days in Aug. 1945	35 30	8 30	0
		T.S.T.		41 45	23 10	2 00
		T.S.		41 35	21 10	2 15
		B.S.		0 30	0	0
	Centre section	T.S.		34 25	9 10	0
		Mdht.		24 50	5 00	0
		B.S.		1 45	0	0
	Root end	T.S.		29 00	16 20	2 40
		Mdht.		0	0	0
		B.S.		0	0	0
	Tip end	Spar	22 days in Sept. 1945	49 45	12 20	0
		T.S.T.		57 35	36 10	0 50
		T.S.		58 15	35 30	1 00
		B.S.		3 35	0 20	0
	Centre section	T.S.		45 00	17 10	0
		Mdht.		18 45	0	0
		B.S.		0	0	0
	Root end	T.S.		52 20	31 00	0
		Mdht.		0	0	0
		B.S.		0	0	0
	Tip end	Spar	23 days in Oct. 1945	17 20	0 30	0

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Master Mainplane Port	Tip end	T.S.T.	23 days in Oct. 1945	21	50	12	20	0	
		T.S.		20	00	14	40	0	
		B.S.		0		0		0	
	Centre section	T.S.		13	30	0		0	
		Mdht.		0		0		0	
		B.S.		0		0		0	
	Root	T.S.		20	00	12	20	0	
		Mdht.		0		0		0	
		B.S.		0		0		0	
Master Mainplane Starboard	Tip end	Spar	14 days in June 1945	65	30	24	50	2	40
		T.S.T.		71	40	44	10	13	00
		T.S.		71	10	43	10	8	20
		B.S.		23	00	0		0	
	Centre section	T.S.		70	10	34	40	1	50
		Mdht.		40	50	2	50	0	
		B.S.		14	30	0		0	
	Root end	T.S.		67	00	34	10	2	50
		Mdht.		57	30	11	00	0	
		B.S.		19	00	1	00	0	
	Tip end	Spar	24 days in July 1945	41	20	9	10	0	
		T.S.T.		53	00	29	10	11	50
		T.S.		53	10	29	10	6	40
		B.S.		1	40	0		0	
	Centre section	T.S.	24 days in July 1945	54	50	24	30	7	00
		Mdht.		19	00	0		0	
		B.S.		0	10	0		0	
	Root end	T.S.		45	20	20	10	2	10
		Mdht.		23	40	2	10	0	
		B.S.		1	30	0		0	

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Master Mainplane Starboard	Tip end	Spar	22 days in Aug. 1945	47	10	10	10	0	
		T.S.T.		47	20	34	50	8	30
		T.S.		49	00	36	40	7	50
		B.S.		3	10	0		0	
	Centre section	T.S.		49	50	36	50	8	50
		Mdht.		23	40	0		0	
		B.S.		0		0		0	
	Root end	T.S.		48	30	23	20	0	
		Mdht.		26	30	0		0	
		B.S.		0		0		0	
	Tip end	Spar	22 days in Sept. 1945	24	10	0		0	
		T.S.T.		30	30	18	20	2	00
		T.S.		32	20	17	30	0	10
		B.S.		0		0		0	
	Centre section	T.S.		31	10	25	00	3	30
		Mdht.		11	20	0		0	
		B.S.		0		0		0	
	Root end	T.S.		27	50	5	20	0	
		Mdht.		3	20	0		0	
		B.S.		0		0		0	
Anson Mainplane Port	L. 1	T.S.T.	7 days in May 1945	48	55	38	40	11	55
		T.S.		47	45	38	15	4	45
		Mdht.		39	00	19	05	0	
		B.S.		24	25	6	40	0	
	L. 8	Top		43	50	29	40	14	45
		Mdht.		37	00	19	20	0	40
		B.S.		32	00	10	30	0	

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Anson Mainplane Port	Spar	Top	7 days in May 1945	44	30	30	50	6	25
		Mdht.		26	25	3	35	0	
		B.S.		8	00	0		0	
	L. 7			29	30	9	20	0	
	Metal			44	45	35	15	7	50
	Tank			42	40	28	20	2	10
	9			47	25	32	00	4	50
	4			43	00	23	40	0	
	4A			41	40	19	25	40	
	L. 3	T.S.T.		48	25	35	40	8	30
		T.S.		47	10	34	50	6	55
		Mdht.		35	15	13	20	0	
		B.S.		21	50	1	55	0	
	L. 1	T.S.T.	24 days in June 1945	147	10	84	15	36	55
		T.S.		145	50	88	45	22	35
		Mdht.		107	25	28	10	0	
		B.S.		65	15	0		0	
	L. 8	Top		149	20	85	55	28	00
		Mdht.		113	25	35	50	1	15
		B.S.		92	10	6	50	0	
	Spar	Top		135	20	57	10	1	20
		Mdht.		81	50	3	55	0	15
		B.S.		14	25	0		0	
	L. 7			81	35	0	05	0	
	Metal			136	05	73	55	2	55
	Tank			125	30	57	10	2	15
	9			136	50	69	05	2	15
	4			121	25	48	00	1	00
	4A			117	30	35	25	0	25

(*contd.*)

TABLE I—(*contd.*)

Wing	Location	Position	Period of observation	Above 50°	Above 60°	Above 70°
1	2	3	4	5	6	7
				h. m.	h. m.	h. m.
Anson Mainplane Port	L. 3	T.S.T.	24 days in June 1945	148 45	83 40	13 50
		T.S.		143 10	79 35	9 10
		Mdht.		112 55	30 15	0
		B.S.		54 55	0	0
Oxford Mainplane Port	Tip end	T.S.T.	6 days in May 1945	44 15	36 05	10 40
		T.S.		43 25	30 35	7 45
		Mdht.		37 30	10 05	0 40
		B.S.		29 15	3 25	0
	Root end	T.S.T.		44 05	29 00	9 15
		T.S.		43 20	27 10	5 30
		Mdht.		35 05	12 20	0
		B.S.		21 45	0 35	0
	L.E.	T.S.		38 55	17 30	1 20
	Spar			46 00	27 00	7 40
	Tip end	T.S.T.	24 days in June 1945	114 35	70 25	12 50
		T.S.		110 55	53 40	3 40
		Mdht.		81 50	17 50	0
		B.S.		59 35	0	0
	Root end	T.S.T.		113 05	67 10	3 50
		T.S.		109 40	61 40	1 15
		Mdht.		83 05	15 55	0
		B.S.		50 10	0	0
	L.E.	T.S.		86 20	33 00	0
	Spar			102 10	55 30	7 30
Oxford Mainplane Starboard	Tip end	T.S.T.	6 days in May 1945	45 40	35 15	14 30
		T.S.		45 10	33 10	12 10
		Mdht.		37 35	12 00	0
		B.S.		23 45	2 25	0

(*contd.*)

TABLE I—(*concld.*)

Wing	Location	Position	Period of observation	Above 50°		Above 60°		Above 70°	
1	2	3	4	5		6		7	
				h.	m.	h.	m.	h.	m.
Oxford Mainplane Starboard	**Tank bulkhead**	**T.S.T.**		**44**	**30**	**32**	**55**	**13**	**55**
		T.S.		**44**	**10**	**32**	**20**	**11**	**15**
		Mdht.		**37**	**10**	**12**	**25**	**0**	**35**
		B.S.		**23**	**15**	**1**	**30**	**0**	
	L.E.	**T.S.**		**43**	**30**	**30**	**55**	**7**	**00**
	Spar			**37**	**25**	**15**	**25**	**0**	**10**
	Tip end	**T.S.T.**	**24 days in June 1945**	**134**	**00**	**70**	**10**	**32**	**10**
		T.S.		**132**	**30**	**73**	**10**	**21**	**05**
		Mdht.		**96**	**20**	**26**	**25**	**0**	
		B.S.		**65**	**00**	**0**		**0**	
	Tank bulkhead	**T.S.T.**		**129**	**35**	**80**	**00**	**27**	**40**
		T.S.		**126**	**00**	**73**	**55**	**18**	**30**
		Mdht.		**97**	**00**	**33**	**55**	**0**	
		B.S.		**59**	**50**	**0**		**0**	
	L.E.	**T.S.**		**130**	**05**	**86**	**15**	**12**	**05**
	Spar			**113**	**10**	**42**	**50**	**0**	

L.—Location.
T.S.T.—Top skin top.
T.S.—Top skin bottom.
Mdht.—Mid-height.
B.S.—Bottom skin top.
L.E.—Leading edge.
T.S.i—Inner top skin.

The average number of hours/day (at Dehra Dun) when the temperatures were above 50°C, 60°C and 70°C are plotted in figures 33, 34 and 35. The maximum temperature gradients attained are given in Table II.

TABLE II

Temperature Gradient in wings

Date	Location	Top °C	Bottom °C	Inner top skin	Difference °C
1	2	3	4	5	6
		ANSON MAINPLANE PORT			
24–5–45	L. 1	•88·2	59·5	..	28·7
	L. 8	81·5	65·5	..	16·0
	L. 3	80·0	58·0	..	22·0
	Spar	74·5	53·0	..	21·5
6–6–45	L. 1	79·0	54·0	..	25·0
	L. 8	73·5	60·0	..	13·5
	L. 3	71·0	59·5	..	12·5
	Spar	66·5	51·0	..	15·5
21–6–45	L. 1	72·0	50·5	..	21·5
30–6–45	L. 1	83·5	50·0	..	33·5
8–8–45	L. 1	77·5	47·5	..	20·0
29–8–45	L. 1	53·5	35·5	..	18·0
		MOSQUITO MAINPLANE STARBOARD			
4–6–45	Leading edge centre	81·0	57·5	..	23·5
	Centre section	68·0 68·0	.. 52·5	63·5 ..	4·5 15·5
6–6–45	Centre mainplane	61·5 61·5	.. 54·5	58·7 ..	2·8 7·0
	Centre section	65·5 65·5	.. 56·2	61·0 ..	4·5 9·3
	Leading edge centre	63·0	40·0	..	23·0
	Leading edge tip	58·0	42·5	..	15·5
21–6–45	Leading edge centre	69·2	48·0	..	21·2
	Centre section	67·5 67·5	.. 41·6	56·5 ..	11·0 25·9
30–6–45	Leading edge centre	77·3	49·8	..	17·5
	Centre section	76·8 76·8	.. 53·5	69·2 ..	7·6 23·3
8–8–45	Leading edge centre	70·9	45·7	..	25·2
	Centre section	63·7 63·7	.. 49·8	60·5 ..	3·2 15·9

(contd.)

TABLE II—(*contd.*)

Date	Location	Top °C	Bottom °C	Inner top skin	Difference °C
1	2	3	4	5	6
	MOSQUITO MAINPLANE STARBOARD				
29–8–45	Leading edge centre	57·8	40·0	..	17·8
	Centre section	53·2 53·2	.. 38·8	44·6 ..	8·6 14·4
	MASTER MAINPLANE PORT				
21–6–45	Tip end	73·5	58·3	..	15·2
	Centre section	66·0	49·5	..	16·5
	Root end	68·3	49·5	..	18·8
22–6–45	Tip end	82·0	59·5	..	22·5
30–6–45	Tip end	76·7	52·0	..	24·7
	Root end	76·7	40·7	..	26·0
4–7–45	Tip end	85·0	51·6	..	33·4
8–8–45	Tip end	68·2	47·5	..	20·7
29–8–45	Tip end	52·5	39·5	..	13·0
	MASTER MAINPLANE STARBOARD				
21–6–45	Tip end	71·0	51·6	..	19·4
	Centre section	69·3	52·0	..	17·3
	Root end	66·5	52·5	..	14·0
30–6–45	Tip end	77·5	52·5	..	25·0
21–7–45	Tip end	80·0	50·5	..	29·5
8–8–45	Tip end	69·2	46·4	..	22·8
22–8–45	Tip end	86·0	50·5	..	35·5
29–8–45	Tip end	55·5	40·0	..	15·5
	OXFORD MAINPLANE PORT				
24–5–45	Tip end	82·2	59·8	..	22·4
	Root end	79·0	59·5	..	19·5
25–5–45	Tip end	81·0	61·0	..	20·0
6–6–45	Tip end	71·6	57·2	..	14·4
21–6–45	Tip end	67·2	54·0	..	13·2

(*contd.*)

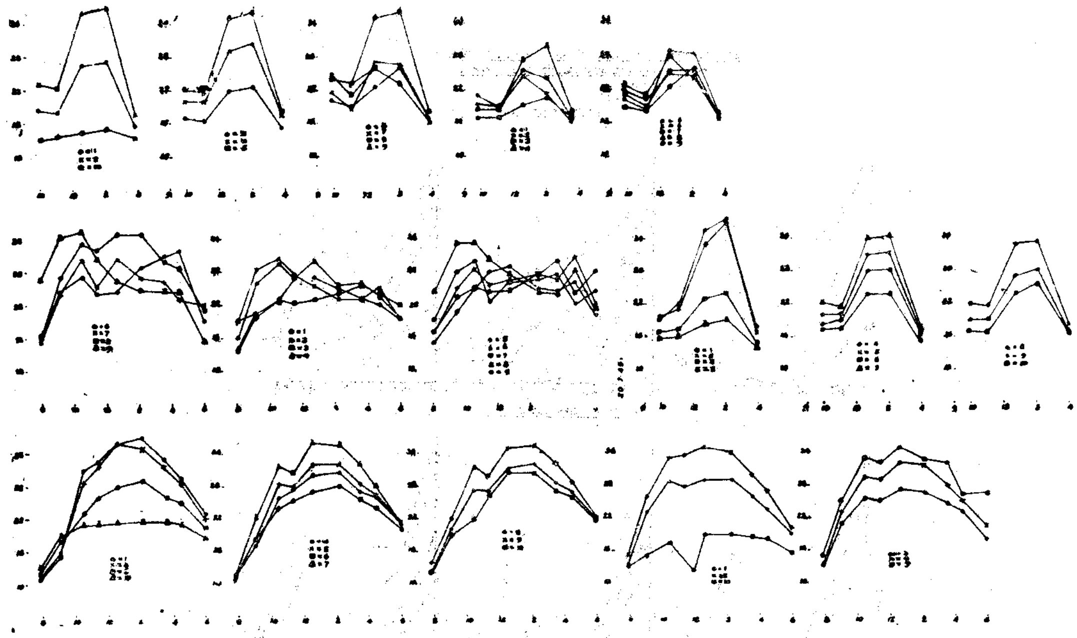


FIG. 30.—Temperature data for Horsa tailplane 11-6-1945, 20-7-1945.

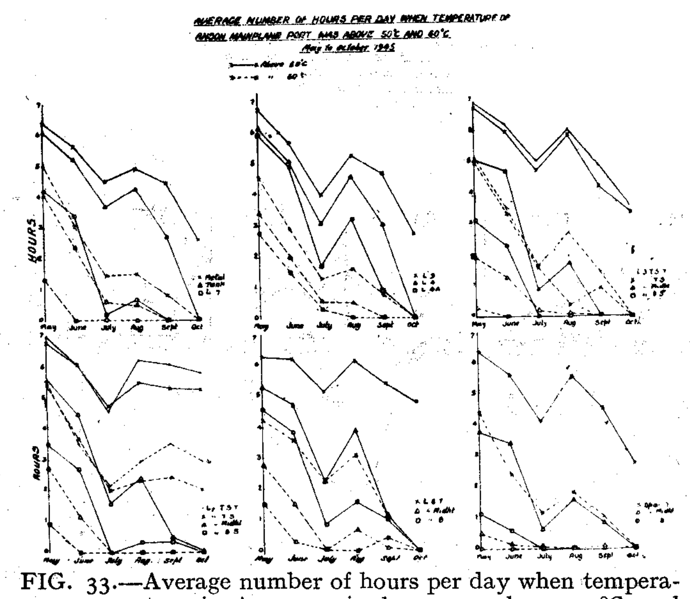


FIG. 33.—Average number of hours per day when temperature in Anson mainplane was above 50°C and 60°C.

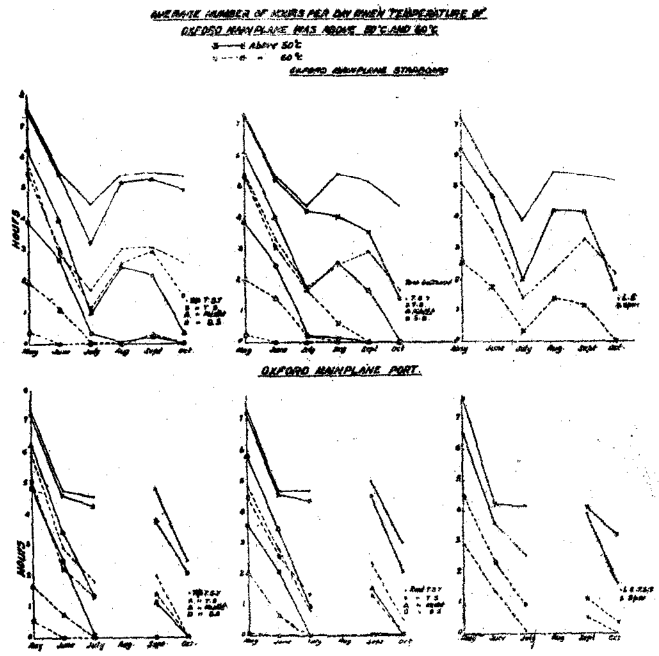


FIG. 34.—Average number of hours per day when temperature in Oxford mainplanes was above 50°C and 60°C.

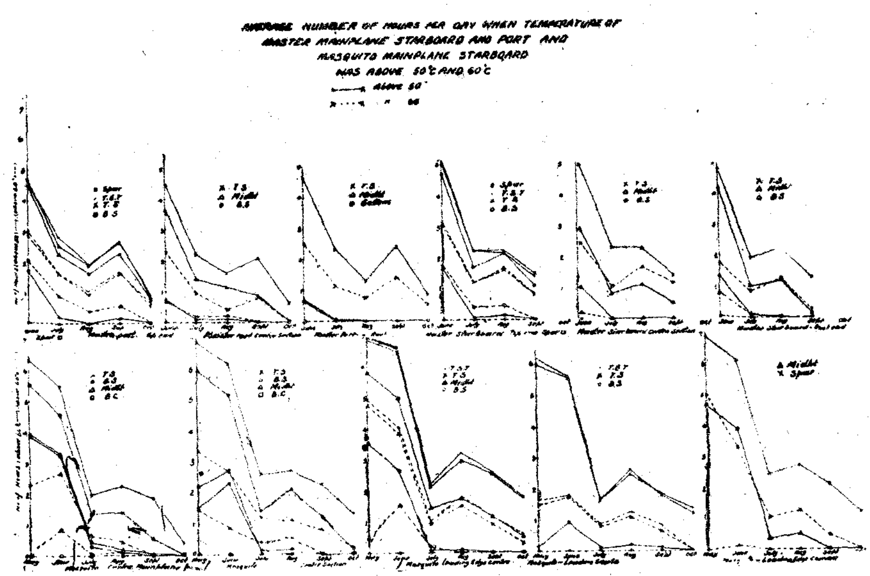


FIG. 35.—Average number of hours per day when temperature in Master mainplanes and Mosquito mainplane starboard was above 50°C and 60°C.

TABLE II—(*concld.*)

Date	Location	Top °C	Bottom °C	Inner top skin	Difference °C
1	2	3	4	5	6
		OXFORD MAINPLANE PORT			
30–6–45	Root end	81·0	50·0	..	31·0
8–8–45	Tip end	67·7	49·7	..	18·0
29–8–45	Tip end	50·0	38·5	..	11·5
		OXFORD MAINPLANE STARBOARD			
24–5–45	Tip end	81·0	59·8	..	21·2
	Tank bulkhead	79·0	56·5	..	22·5
25–5–45	Tank bulkhead	84·0	59·8	..	24·2
6–6–45	Tip	73·0	51·5	..	21·5
21–6–45	Tip	76·0	52·3	..	23·7
3–8–45	Tank bulkhead	71·7	45·5	..	26·2
8–8–45	Tip	68·5	49·5	..	19·0
29–8–45	Tip	50·0	38·5	..	11·5

As can be seen from the Tables and Figures, during summer, the top skin temperature remained at a stretch for over 6 hours over 60°C on many days. In the *Anson*, in May excepting the bottom of the spar all locations (including the bottom skin) attained a temperature of over 60°C, which was about 10°C higher than the black body temperature. Only the top surface and mid-height in some locations went above 70°C. In June during 24 days some locations remained above 60°C up to 69 hours. The bottom skin was above 60°C up to 7 hours. Temperatures above 70°C lasted up to a total of 37 hours. Occasionally even at mid-height 70°C was attained. The area under the curves in Fig. 33, 34 and 35 can be taken to indicate the severity of the conditions prevailing in the wings. This is collected together in Table III.

TABLE III

Index of severity as shown by the area under the curves giving the average number of hours per day when temperature in the wings was above 50°C and 60°C for the period
(Figs. 33, 34, 35)

Wing	Location	Temperature	Area-units	Wing	Location	Temperature	Area-units
			JUNE–OCTOBER				
Master Port	Spar	50 60	57·0 19·1	Master Starboard Root	B.S.	50 60	4·9 0·3
Tip	T.S.T.	,,	65·0 39·3	Anson L. 1	T.S.T.	,,	149·4 75·6
,,	T.S.	,,	63·2 39·3	,,	T.S.	,,	138·3 61·3
,,	B.S.	,,	8·2 0·3	,,	Mdht.	,,	42·4 3·0
Centre	T.S.	,,	55·5 21·8	,,	B.S.	,,	14·3 0
,,	Mdht.	,,	34·2 5·5	L. 8	T.S.	,,	140·3 52·9
,,	B.S.	,,	3·8 0	,,	Mdht.	,,	62·3 9·9
Root	T.S.	,,	57·3 32·3	,,	B.S.	,,	34·0 4·2
,,	Mdht.	,,	2·2 0	Spar	Top	,,	118·2 33·8
,,	B.S.	,,	2·4 0	,,	Mdht.	,,	30·3 1·7
Master Starboard Tip	Spar	,,	43·7 11·5	,,	B.S.	,,	2·1 0
,,	T.S.T.	,,	49·8 31·1	Metal		,,	116·5 33·0
,,	T.S.	,,	50·2 31·5	Tank		,,	85·7 15·2
,,	B.S.	,,	7·0 0	L. 7		,,	15·8 0·0
Centre	T.S.	,,	50·6 29·7	L. 9		,,	117·4 32·3
,,	Mdht.	,,	24·2 0·8	L. 4		,,	84·9 13·0
,,	B.S.	,,	3·4 0	L. 4A		,,	52·9 6·9
Root	T.S.	,,	47·3 20·0	L. 3	T.S.T.	,,	134·2 48·6
,,	Mdht.	,,	28·5 3·5	,,	T.S.	,,	125·2 28·9

(*contd.*)

TABLE III—(*contd.*)

Wing		Location	Temperature	Area-units	Wing		Location	Temperature	Area-units
				JUNE–OCTOBER					
Anson	L. 1	Mdht.	50 60	31·7 5·8	Mosquito Mainplane Starboard	Leading edge centre	T.S.T.	50 60	79·4 40·9
	,,	B.S.	,,	7·4 0·0		,,	T.S.	,,	76·2 35·3
Mosquito Mainplane Starboard	Centre mainplane	T.S.	,,	57·4 15·5		,,	Mdht.	,,	45·7 6·3
	,,	T.S.i	,,	36·2 4·1		,,	B.S.	,,	9·9 0·0
	,,	Mdht.	,,	15·0 0·0		Leading edge tip	T.S.T.	,,	61·0 24·1
	,,	B.S.	,,	12·6 0·0		,,	T.S.	,,	61·0 21·9
	Centre section	T.S.	,,	72·1 30·4		,,	B.S.	,,	6·0 0·0
	,,	T.S.i	,,	45·0 10·3		Leading edge carriage	Mdht.	,,	18·7 0·4
	,,	Mdht.	,,	10·2 0·0			Spar	,,	71·1 28·6
	,,	B.S.	,,	8·0 0·0					
				MAY–OCTOBER					
	Centre mainplane	T.S.	60 50	96·8 31·4	Mosquito Mainplane Starboard	Leading edge centre	Mdht.	50 60	81·3 12·8
	,,	T.S.i	,,	67·9 6·1		,,	B.S.	,,	30·2 0
	,,	Mdht.	,,	38·1 0		Leading edge tip	T.S.T.	,,	101·2 36·6
	,,	B.S.	,,	36·5 0		,,	T.S.	,,	99·1 33·2
	Centre section	T.S.	,,	115·0 48·3		,,	B.S.	,,	9·4 0
	,,	T.S.i	,,	84·0 16·4		Leading edge carriage	Mdht.	,,	46·3 1·0
	,,	Mdht.	,,	27·1 0			Spar	,,	112·9 55·3
	,,	B.S.	,,	21·0 0	Anson		L. 1 T.S.T.	,,	190·1 96·4
	Leading edge centre	T.S.T.	,,	122·2 69·5			L. 1 T.S.	,,	178·1 92·0
	,,	T.S.	,,	118·6 63·2			L. 1 Mdht.	,,	75·8 16·4

(*contd.*)

TABLE III—(*concld.*)

Wing	Location	Temperature	Area-units	Wing	Location	Temperature	Area-units
			MAY-OCTOBER				
Anson Leading edge carriage	L. 1 B.S.	50 60	33·4 2·9	Anson Leading edge carriage	L. 3 T.S.	50 60	167·1 56·4
	L. 8 T.S.	,,	186·1 78·5		,, Mdht.	,,	64·0 16·8
	L. 8 Mdht.	,,	95·1 23·4		,, B.S.	,,	24·8 1·2
	L. 8 B.S.	,,	61·2 9·6	Oxford Starboard Tip	T.S.T.	,,	177·9 97·5
	Spar Top	,,	157·9 55·9	,,	T.S.	,,	164·7 85·7
	,, Mdht.	,,	53·6 3·2	,,	Mdht.	,,	84·5 16·1
	,, Bottom	,,	7·2 0	,,	B.S.	,,	34·3 1·7
	Metal	,,	155·9 59·7	Tank Bulkhead	T.S.T.	,,	170·1 91·5
	Tank	,,	122·9 34·7	,,	T.S.	,,	138·4 52·7
	L. 7	,,	40·9 4·6	,,	Mdht.	,,	84·6 17·8
	L. 9	,,	157·3 56·0	,,	B.S.	,,	32·4 0·9
	L. 4	,,	122·0 31·0		Leading edge	,,	171·1 92·8
	L. 4A	,,	87·9 20·6		Spar	,,	123·3 38·9
	L. 3 T.S.T.	,,	177·4 77·0				

(*To be continued*)

FIRST RECORD OF THE GENUS *EUCLASTA* FRANCH. (GRAMINEÆ) IN INDIA

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The genus *Euclasta* of the family Gramineæ was founded by Franchet in 1895 with its only species *Euclasta glumacea* Franch. as the type. In 1917 Stapf discovered that Franchet's plant was the same as *Andropogon condylotrichus* Hochst. ex Steud. (1854), or *Andropogon piptatherus* Hack. (1878) [= *Sorghum piptatherus* (Hack.) O. Ktze., *Amphilophis piptatherus* (Hack.) Nash] ; and hence Stapf (1917) 181 named the plant as *Euclasta condylotricha* (Hochst.) Stapf.

Stapf (1917) 182, Bews (1929) 247 and Pilger (1940) 161 record the occurrence of this grass in Tropical Africa and in Tropical America from Mexico to Brazil.

Recently, while examining some of Dr. H. F. Mooney's collections from Central Provinces, India we came across a specimen which could not be fitted in any genus so far recorded from India. It approached *Dichanthium* Willem. very closely but differed from it in having hyaline joints and pedicels. From *Capillipedium* Stapf it differed in having the lowest 1–3 pairs of spikelets homogamous. The specimen was consequently sent to Dr. N. L. Bor, Assistant Director, Royal Botanic Gardens, Kew for opinion, and he has identified it as *Euclasta condylotricha* (Hochst.) Stapf.

This is the first record of the genus *Euclasta* from India, and since this grass has been collected from a locality of most average climatic conditions, it is hoped that it will also be found to occur elsewhere in India. The object of publishing an illustrated account of this grass is to familiarize the botanical workers and collectors in India with its structure.

Euclasta Franchet, Bull. Soc. Hist. Nat. VIII (1895) 335. Annual grass with usually branched many-noded bearded culms. Panicles of few to 15 usually nodding racemes, with long beards from the nodes. Spikelets binate, one sessile, the other pedicelled, more or less similar in shape, different in sex except the lowermost 1–3 pairs of each raceme which are homogamous (male or neuter), in many-jointed delicately peduncled nodding sub-digitate or corymbose or sub-panicled racemes ; joints and pedicels filiform, much compressed, hyaline and balsamiferous between the thickened margins, disarticulating horizontally, except in the sterile basal portion of the raceme ; fertile sessile and pedicelled spikelets deciduous, the former with the adjacent joint and pedicel, but the sterile basal pairs persistent. Florets 2 in the fertile sessile spikelets (lower reduced to an empty glume III and upper bisexual), 2 or 1 in the barren sessile and all the pedicelled spikelets, male or neuter or quite suppressed. Fertile sessile spikelets dorsally compressed, awned ; callus small, minutely bearded. Glume I and II equal, thinly chartaceous ; Gl. I truncate, 2-keeled, with the margins narrowly and sharply inflexed down to the middle, thence slightly involute ; Gl. II boat-shaped, 3-nerved, keeled ; Gl. III small, hyaline, nerveless ; Gl. IV reduced to a hyaline, upwards firmer linear stipe, passing into a perfect awn. Palea 0. Lodicules 2, minute, glabrous. Stamens 3 ; anthers of hermaphrodite spikelets minute, about as long as broad, of male spikelets larger, several times longer than broad. Stigmas slender, exserted laterally above the middle or near the tips of the spikelets, suberect. Grain obovoid oblong, subobtuse, dorsally compressed ; embryo rather more than half the length of the grain. Pedicelled and barren sessile spikelets similar to fertile sessile but somewhat larger and usually differing in color. Glume I many-nerved, Gl. II equal or unequal.

Euclasta condylotricha (Hochst.) Stapf Fl. Trop. Afr. IX (1917) 181.

An annual grass. Culms about 1·5 m. high, usually geniculately ascending and often rooting from the lowest nodes, or more or less erect, slender, usually branched, terete

smooth. Leafsheaths terete, tight or the upper and those supporting a branch slightly inflated, striate, glabrous or sparingly hairy, particularly along the upper margins and at the mouth, rarely softly hairy all over, always bearded at the nodes ; ligules short membranous, ciliate ; blades linear, long-tapering to a setaceous point, more or less attenuated towards and contracted at the base, up to 30 cm. long and 4–8 (rarely more) mm. wide, somewhat flaccid, green, usually hairy below and very sparingly so above, the hairs fine, soft, springing from minute tubercles, rarely glabrous, margins and nerves near them rough, midrib very slender, whitish above, primary lateral nerves 3–4 on each side, very fine. Panicles terminal and from the intermediate and upper branches, usually shortly exserted, the lateral often very scanty (sometimes reduced to a solitary raceme) ; primary axis filiform, up to 1 ·2 cm. long ; branches simple or the lowest sometimes very sparingly again divided, subcapillary, about 1 ·2 cm. long, flexuous, usually nodding or sometimes sigmatoid, glabrous ; hairs at the nodes spreading, nearly 4 mm. long. Racemes flexuous, rather loose when ripe, very readily breaking up down to the persistent barren basal portion, 2 ·5–5 cm. long ; joints and pedicels of the fertile part of the raceme very similar, about 2 mm. long, densely and shortly ciliate, cilia equally long, transparent portion green, often at length turning black and then very conspicuously contrasting with the white fringe of cilia. Fertile sessile spikelets oblong, pale to almost whitish, 4 mm. long. Glume I minutely truncate, more or less hairy towards the base and on the sides, keels scaberulous, intracarinal nerves 4–5, ending below the hyaline tip ; Gl. II acute to subobtuse ; Gl. III ovate, about 1 ·5 mm. long, glabrous ; awn 2 ·5–4 cm. long. Anthers up to about 1 ·5 mm. long. Grain less than 2 mm. long. Pedicelled and barren sessile spikelets 5–6 mm. long, oblong to lanceolate-oblong. Glume I very minutely truncate to subacute, more or less hairy, often from the tubercles, nerves 10–17, very marked and prominent in the spikelets of the basal barren portion ; Gl. II shorter, 3–5 nerved, ciliolate upwards ; Glumes III and IV oblong to linear, shorter than Gl. I or quite small. Anthers linear, up to 2 mm. long.

Dongargarh, Khairagarh State, C.P., Mooney—2365, 21–10–1943 ; "A slender straggling grass climbing among the bushes up to 5 ft. at foot of granite hill".

EXPLANATION OF PLATE

a—Upper part of the culm with panicles.
b—Culm, leafsheath and blade.
c—Lowest homogamous spikelets of a raceme.
d—A panicle.
e—A joint of the rhachis (hyaline).
f—Pedicel of the pedicelled spikelet (hyaline).
g–i—Glumes I to III (of sessile hermaphrodite spikelet).
j—Glume IV with awn (of sessile hermaphrodite spikelet).
k—Ovary with stigmas.
l—Stamens.
m—Lodicules.
n—Gl. I of pedicelled spikelet.
o—Gl. II of pedicelled spikelet.
p—Mouth of leafsheath showing ligule.

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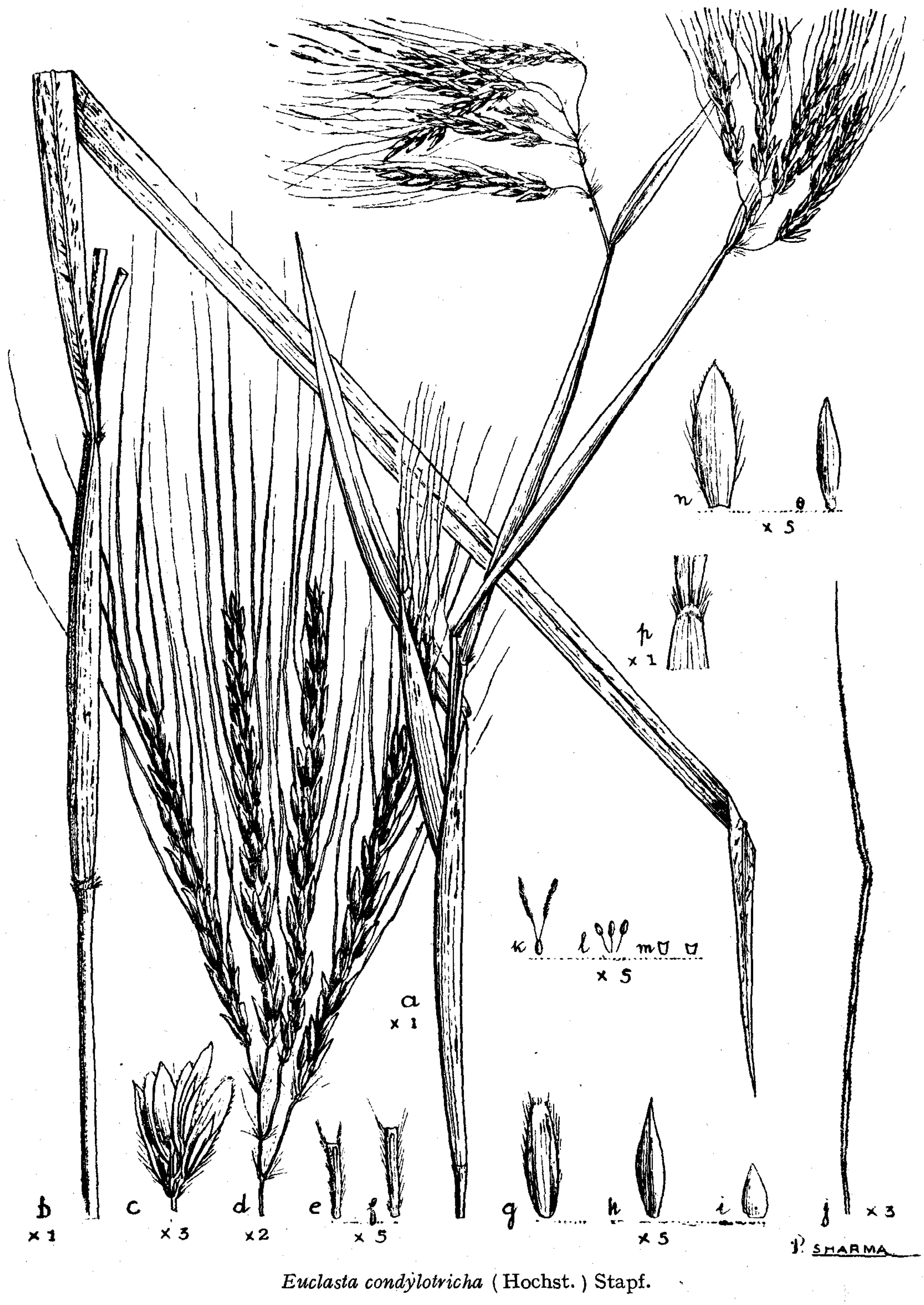

Euclasta condylotricha (Hochst.) Stapf.

MORTALITY OF *CASUARINA EQUISETIFOLIA* FORST.

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ABSTRACT

Deficiencies of water and nutrients are believed to be the causes of failure of Casuarina in the localities inspected. Trees thus weakened are, in some cases, attacked by *Trichosporium vesiculosum* which hastens their death.

Manuring in pits prior to transplanting, deep planting and watering in the initial stages will raise a vigorous stand. Leaf litter should not be removed from the plantations.

T. vesiculosum may be controlled by preventing pruning and lopping of branches, trenching and other sanitary practices.

Casuarina equisetifolia Forst. is extensively grown in coastal as well as inland areas of South India. Due to its quick growth (rotation varies from 6–10 years in Madras and is 18 years in Puri) and high calorific value of the wood, Casuarina is suitable as a fuel wood. Since the species can grow on sand, Casuarina has been extensively tried in coastal areas to fix sand dunes, protect sea coasts from erosion, afford shelter from high winds and storms and add beauty to the shore. Failures have, however, been reported for some time from the east coast and inland plantations and they have aroused a great concern to the States. Opinions vary as to the reasons of such failures. Some believe that the plants die due to extreme drought which these places had been experiencing for the past few years. Others ascribe it as due to attack by the fungus *Trichosporium vesiculosum* Butler. Bose (1947) is of opinion that *Phomopsis casuarinae* lives symbiotically with Casuarina and the fungus is seed borne. Under certain conditions when the vitality of the tree is lowered, the symbiont becomes parasitic. Hyphæ can usually be demonstrated in the seed-coat as pointed out by Bose. Isolations from dying and dead trees in the field, however, failed to yield *P. casuarinae* in culture and in my opinion this fungus is not connected with the widespread mortality of Casuarina.

The writer undertook a tour in June–July 1950, to inspect Casuarina plantations in Sriharikota range, Nellore division ; and Padugais of Caveri, Tiruchirapalli division—both in the Madras State and Balukhand range, Puri division in the Orissa State. Investigations reported in the following sections are based on observation on these areas only.

SRIHARIKOTA RANGE

Sriharikota is a small island lying between the Bay of Bengal and the Pulicat lake, in Nellore district. It is about 25 miles long and its breadth varies from 1 to 5 miles. The centre of the island is about 47 miles by canal from Madras. The average rainfall of the island as recorded between 1921–31 (Law, 1935) is 40–50 inches in the year. A record of rainfall in different parts of the island during 1944–49 is given below.

TABLE 1.—*Showing distribution of monthly rainfall in different parts of Sriharikota island during 1944–49*

Year	Localities	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1944	Kothachenu ..	..	..	7·3	..	..	1·0	5·1	1·7	1·0	7·2	29·2	3·2	55·7
	Ponna	7·4	..	..	..	..	..	6·1	1·75	0·75	6·25	27·2	3·8	53·25
	Chengalapalem ..	..	..	..	..	..	..	2·6	2·4	..	7·8	28·8	4·5	46·1
	Sondladoruvu ..	..	..	..	1·2	..	1·7	4·4	..	3·3	8·2	19·8	..	38·6
	Ramanappachattaram	..	..	..	..	..	..	3·8	2·5	29·8	2·6	..	..	38·7
1945	Kothachenu ..	..	..	..	2·3	..	..	5·1	6·3	2·8	2·5	13·4	..	32·4
	Ponna	..	..	..	1·7	..	..	3·3	6·4	1·9	1·0	14·8	..	29·1
	Chengalapalem ..	..	..	..	1·2	..	0·4	3·4	7·0	1·2	..	13·2	..	26·4
	Sondladoruvu ..	..	..	..	1·2	..	..	4·4	6·12	2·3	2·53	10·46	..	27·01
	Ramanappachattaram	..	..	..	1·1	..	0·8	..	4·3	1·7	0·6	16·6	..	25·1
1946	Kothachenu ..	0·4	..	..	..	..	2·8	3·6	3·2	2·4	8·6	22·6	33·0	76·6
	Ponna	..	..	..	..	..	2·0	1·5	2·5	2·55	3·81	16·24	27·4	56·0
	Chengalapalem ..	..	..	..	..	..	2·0	1·9	2·3	2·0	13·2	19·4	29·5	70·3
	Sondladoruvu ..	..	..	..	..	..	2·7	1·8	2·4	1·2	6·72	14·69	31·0	60·51
	Ramanappachattaram	..	..	..	..	..	2·0	1·9	2·1	2·8	3·8	17·4	32·0	62·0
1947	Kothachenu ..	4·6	..	..	1·0	..	..	5·1	1·1	4·3	7·0	4·1	1·8	29·0
	Sondladoruvu ..	5·0	0·8	..	..	..	..	3·2	1·2	2·98	4·25	1·35	1·56	20·34
	Ramanappachattaram	5·4	0·5	..	..	..	..	3·8	1·0	2·4	4·0	1·4	1·3	19·8
1948	Kothachenu ..	0·5	0·4	..	..	..	..	1·2	1·2	0·6	5·0	14·5	0·4	23·8
	Chengalapalem ..	..	..	..	..	..	..	1·2	1·0	0·8	2·1	6·2	0·8	12·1
	Sondladoruvu ..	0·32	0·20	..	..	..	..	1·8	0·5	0·2	1·03	7·19	0·54	11·78
1949	Kothachenu ..	..	..	..	..	6·4	2·0	7·31	9·80	4·1	1·0	7·56	..	38·17

The soil is coarse or fine sand. The water-table varies from 10–12 feet and may rise as high as 6–8 feet during rains. The plantations inspected were raised during 1944 to 1946 and failure of Casuarina in them could be grouped into two classes : in one the trees had grown tall (50–60 feet high on average) and healthy for the first 3–4 years, mortality appearing after that period. This condition was seen in plantations of Kothachenu and parts of Chengalapalem situated away from the sea and of Ponna and parts of Sondladoruvu adjoining the sea coast. The dying trees exhibited wilting, the needles turned yellow and later dried up. A few apparently dead trees put forth a flush of green needles amidst dried ones. Some of the lateral roots were dead and the nodules shrivelled and turned black, indicating a loss in function of nitrogen fixing bacteria within them. Such trees died eventually and the dead trees were found in groups. Their wood exhibited a blackish brown discolouration and emitted a fruity alcoholic smell. Occasionally one came across dead trees showing an attack by *Trichosporium vesiculosum,* which was manifested by the development of a thick coating of spore mass, black in colour, underneath the blistered or ruptured bark. No such evidence of the fungus was seen on dying trees and once, it was observed on a green healthy tree where the fungus developed the spore mass on the stem beneath a wound caused by pruning of a branch (Pl. I, Fig. 1). This particular instance was seen in Ponna where the air was highly humid due to proximity of the place to sea. Splashing of waves developed mists of water particles which were blown against the trees by a strong wind so that the bark of such trees was wet. Spores of *T. vesiculosum* lodged on the wound caused by pruning of the branch and a highly humid air, so essential in the germination of a spore and its subsequent infection, helped the fungus in attacking the tree. *T. vesiculosum* has since been shown to be a wound parasite (Marudarajan *et al,* 1950). But as already pointed out, cases of association of the fungus with dying or dead trees were so few that one of the essential prerequisites of Koch's (1882) postulates was not satisfied for holding the fungus as the primary pathogen responsible for the death of trees.

In the second group, the plantations were a complete failure (Pl. I, Fig. 2). Such cases were seen in Ramanappachattaram and parts of Sondladoruvu and Chengalapalem, all situated away from the sea coast. Casuarina in these areas, which was 3–4 years old, was stunted in growth and the average height was only 6–7 feet. The plants presented a bushy habit due to development of some weak branches from the base and from these branches the main leader could not be distinguished. Needles turned yellow. A few lateral roots along with their nodules had dried up. No fungus was observed on them. There was an intensive outbreak of a bark-eating caterpillar (Inderbelidæ, Lepidoptera) indicating an unhealthy condition of the crop. The insect attack was also seen on apparently healthy trees in Ponna and other areas and was regarded as secondary.

Table 1 gives monthly rainfall during 1944–1949 in different plantations which were raised during the period in Sriharikota island. It is evident from the table that excluding the years 1944 and 1946 when the rainfall was normal, the places had been experiencing a severe drought during remaining years including 1950 (not shown in the table). Secondly most of the rainfall was restricted, if not solely confined, between July and December. Such prolonged periods of drought are detrimental to plants. In Casuarina, the tap root goes down 4–5 feet while the laterals remain within 4–8 inches or so from the surface. The latter constitute the major portion in the root-system of the plant. The superficial roots are well adapted to absorb the little aerial condensation that occurs in these areas but with prolonged periods of drought, the lateral roots suffer from lack of such water. Sandy soils, moreover, have less retentive power of holding rain-water. Though water-table is high, enough capillary action is not developed in sandy soils, especially where the sand particles are coarse, to raise water from the water-table to the surface. The tap root alone cannot meet the water

requirement of the plant which, therefore, suffers from a water deficit disturbing the performance of vital functions.

It is reported that previous plantations in this island were promising : this was probably due to good rainfall during that period. The secret of success of Casuarina in sandy soils, which otherwise contain little nutrients, lies in the fact that the bacteria inside the nodules of roots fix atmospheric nitrogen and thus enrich the soil. Low moisture in the substratum appears to be a limiting factor in the functioning of root nodules which shrivel and dry up. A main source of replenishing the soil with nitrogen is therefore lost. Thus drought coupled with deficient nutrition result in weaklings which keep on struggling for life for sometime till they succumb. The same reasons also explain the death of adult trees. The thrifty development of trees in coastal plantations (Pl. I, Fig. 3) is probably due to proximity to sea where, as already explained, the air is very humid. *T. vesiculosum* was found on only a few dead trees. The attack of the fungus was secondary but all the same, it brings about a rapid wilt of the affected trees. This aspect will be examined fully in the next section.

PADUGAIS OF CAVERI

Casuarina plantations in this locality were raised in the river bed of Caveri (Pl. II, Fig. 7) mostly during 1944 to 1946 as a first rotation crop. Trees were stouter and taller than those in Sriharikota island due probably to the sandy loam soil which is naturally rich in nutrients. Mortality was of the first type only as described for Sriharikota island with dying trees exhibiting the same symptoms. A flood in the Caveri in one rainy season during early age of these plantations created a water-logged condition which was as detrimental to plants as drought which occurred in subsequent years. These factors predisposed the trees to infection by *T. vesiculosum* which hastened the wilting of the trees.

STUDIES ON TRICHOSPORIUM VESICULOSUM

1. *Frequency of occurrence of the fungus on Casuarina.*—An actual count of a part of 1944 plantation in Lalapet indicated that out of 1,683 trees which should have been normally present in the area, only 931 trees, i.e., about 55 per cent were standing, the remaining 45 per cent casualties being removed earlier. The standing trees could be put under 5 groups as shown in Table 2.

TABLE 2.—*Showing number of healthy and diseased trees* (for details see text)

Trees	Number	Percentage to	
		Standing trees	Dead and dying trees
Healthy	483	51·8	
Dead without evident fungus under bark ..	306	32·8	
Dying without evident fungus under bark ..	98	10·5	
Dead with fungus spores under bark	43	4·6	9·8
Dying with fungus spores under bark	1	..	

Manifestation of the fungus in the form of spores under bark was not seen on healthy trees and was present on few of the dead trees (Pl. I, Fig. 6). Some dying trees showing no evidence of the parasite under bark were sampled from roots and stems in $1\frac{1}{2}$ feet sections and brought to Dehra Dun. Within a couple of months, many such samples showed blisters in the bark which ruptured and exposed spore mass of *T. vesiculosum.* The fungus was also isolated in culture when pieces of wood from the samples were transferred aseptically to agar. This suggests that some trees, at any rate, carried a latent infection of the fungus in the field. Hence trees exhibiting fungus sporulation under the bark constituted a certain proportion of trees attacked by the parasite. Again, trees exhibiting sporulation of the fungus under bark either high up on the tree only or at its base or roots were similarly sampled along their lengths. Examinations revealed that the fungus was present in apparently sound pieces. Butler (1905) who first recorded the disease in India also observed few trees with the fungus under bark in plantations where mortality was high. · Desiccation of the host carrying a pathogen with an outside hot and humid atmosphere helps the fungus to come out of the host and sporulate. Dry atmosphere in the plantations retarded sporulation of the fungus. This probably explains the low incidence of trees showing manifestation of the fungus in the field. On the other hand, when the dying trees were sampled, it helped in their rapid drying and when such pieces were brought to Dehra Dun in July when the atmosphere was hot and highly humid, the pathogen came out of the host and sporulated. A bluish black sterile mycelium on agar was sometimes isolated in addition to *T. vesiculosum* but the identity and pathogenicity of the former has not been determined as yet.

2. *Mode of infection and spread of the disease.*—The pathogenicity of *T. vesiculosum* has been proved by Marudarajan *et al* (1950) by placing pure cultures of the fungus under bark of Casuarina near ground level. The infected trees began to wilt in 6 months and were dead in 8 months after inoculation. The authors state that the fungus is a wound parasite probably gaining entrance into trees through bark which ruptures normally in nature. The phenomenon of cracking of bark does not, however, appear to be a normal feature. Even if it were so with such a quick-growing species as Casuarina, a callus would develop underneath the wound before the bark splits open and the callus would prevent infection of any fungus. Pruning of lower branches of trees when the latter are 3 years old is practiced in plantations of South India. Spores of *T. vesiculosum* are small, light and powdery and are, therefore, readily disseminated by wind. They lodge on cut ends of stems when branches are pruned and cause infection. Such a mode of infection does not appear to be high from field evidences because of the lack of a humid atmosphere which is essential for spore germination and subsequent infection of trees.

After the infection is established, the fungus travels both up the stem and down into roots and in the latter, the fungus is mostly found in the laterals (Pl. II, Fig. 8), both at the proximal and distal ends. Subsequent spread of the disease occurs through the soil possibly by root contact and root grafting, features which commonly occur in the field (Pl. II, Fig. 9). Dead roots may form footholds of attack by the fungus. Spores were seen in the soil in the immediate vicinity of infected roots and these may also be washed down to roots of healthy trees to cause infection. Hyphae were rare in the soil and *T. vesiculosum* has a limited capacity of free mycelial spread in the soil. Since the lateral roots spread up to 10–12 feet (sometimes more) from the main stem and the spacing of trees is usually 7 feet, the diseased roots are potentially capable of infecting healthy roots by root contact or root grafting within a radius of 20–24 feet. Secondary spread of the disease through the soil is evidenced by the distribution of diseased trees in groups.

3. *Symptoms of trees attacked by T. vesiculosum.*—The fungus attacks trees which are weakened by drought and deficient nutrition in the soil. The affected trees, therefore, present

the same symptoms as described for dying trees. In addition, the bark is raised up into great blisters (Pl. I, Fig. 4) which rupture subsequently. The ruptured bark is thrown out in the form of scales (Pl. I, Fig. 5) and the black powdery mass of spores, about 0·1–0·2 inches thick, is exposed. There is an opinion among Forest Officers that trees fruit more heavily than normal when attacked by the fungus. Such a correlation could not be seen in the field and dead and dying trees, with or without manifestation of the fungus under bark, may bear numerous fruits or the latter may be scantily developed or absent.

4. *Pathology of T. vesiculosum on the host.*—Mycelium of the fungus is present in all the living and dead cells of the wood. The cambium is killed and preponderance of hyphae in the conducting cells suggests that the fungus hinders in the flow of sap. The water supply to the crown which is already below normal due to drought is further depleted by the fungus as a result of which the crown wilts rapidly and dies.

BALUKHAND RANGE

The Balukhand plantations are situated near Puri along the coast of Bay of Bengal. The rainfall is on average 50–60 inches in the year, most of which falls during July to September. Water-table which is 8 feet in May before the break of monsoon may rise to 1 foot in rains. The soil is fine or coarse sand. Mortality had been reported since 1922 when the earliest plantations started in this area were 3–6 years old.

Failures of Casuarina belong to two groups with the same general symptoms as described for plants in Sriharikota island. *T. vesiculosum* is not present in this area. Fruit-bodies of *Ganoderma lucidum* were seen at the bases of some mature trees. The fungus is a root parasite and hastens the death of trees already weakened by drought.

Some plantations near the Sur lake Cut were a complete failure. In 1931, the Cut was made from the Sur lake (situated near this range) through the plantations to the sea in order to reduce the inland flood menace. The Cut was subsequently deepened in 1940–41. The mortality of Casuarina which was so long believed to be due to water-logging was subsequently explained as due to lowering of the water-table as a result of the Cut (Nicholson, 1946). A history of the plantations on the two sides of the Cut shows that all plantations immediately adjoining it except one were raised after the deepening of the Cut in 1940–41. Trees in all these had grown tall though drying up was occurring in isolated areas. These plantations were certainly better than some completely failed plantations situated away from the Cut. Thus if the theory of lowering of water-table explains the development of failure plantations, it does not explain why trees immediately adjoining the Cut had grown tall. Soil acidity was once believed to be affecting the growth adversely but tests carried out disproved this theory as they show the soil to be definitely alkaline (Mooney, 1932). The research report (1930–31) of the Silviculturist, Bihar and Orissa, showed that there was a gradual rise and fall of the water-table in both good and failed areas without showing any correlation and the theory of sudden fluctuation of the water-table being responsible for casualties was found untenable. The report further showed some correlation between percentage of coarse sand particles and the intensity of mortality. The area where casualties had occurred contained a higher percentage of coarser sand particles than one which is free or almost free from casualties.

Amidst failed areas where plants were stunted, there were seen some well developed trees in patches. The latter represented areas where old nurseries had existed. Soils in such areas were evidently manured while raising the nurseries and 'good soil' appeared to be the

reason for promising growth of trees. The attack of a few weaklings by an insect, *Zeuzera coffeae*, was regarded as secondary.

Thus failure of Casuarina in Balukhand could be ascribed to the same general reasons—deficient moisture and nutrients in the soil—which explained the mortality of plants in other areas. Fungus and insect attacks were of a secondary nature.

CONTROL OF CASUARINA MORTALITY

It is evident from the foregoing account that Casuarina has failed in these places due to successive failure of monsoons combined with deficiency in soil nutrients. Though water-tables are high, enough capillary force is not developed by sand particles, especially when they are coarse, to raise the water from the water-table to surface where most of the roots lie. The tap roots alone cannot meet the water requirement of plants which, therefore, suffer from a water deficit disturbing the vital functions. Low moisture, limits the development of root nodules which enrich the soil with nitrogen in an otherwise barren substratum. Drought and deficient nutrition weaken the trees which wilt away and in some places predispose them to infection by *Trichosporium vesiculosum* or *Ganoderma lucidum*.

Control measures should, therefore, be directed to improve the vigour of the plants at an early age. Manuring in pits before transplanting seedlings will maintain a vigorous stand. Frequent watering of seedlings which is practised during the first two years in plantations should be continued under strict vigilance. Deep planting will ensure the development of a long tap root system and at the same time discourage too many superficial spreading laterals. All these will help in the formation of a vigorous tap root system with its numerous side branches which will be able to draw water from the water-table and meet the water requirement of the plant from third year when watering is discontinued. The practice of removing leaf litters from Casuarina plantations should be stopped, since leaf litters decompose to form humus and thus enrich the soil and at the same time improve its texture.

A vigorous stand is likely to ward off the attack of pathogens like *T. vesiculosum* or *G. lucidum*. All the same, suggestions for the control of the former include stoppage of pruning to prevent the fungus which is a wound parasite, from causing infection. Illicit lopping of branches should be prevented with a view to the same end. The secondary spread of *T. vesiculosum* occurs through soil and diseased trees occur in the field in groups. The age-old method of trenching the diseased areas to prevent soil-spread of the disease is not normally recommended but may be practised in exceptional circumstances when care should be taken to disinfect the cut ends of roots inside trenches so exposed by fungicides. Deep planting will discourage shallow, wide-spreading laterals and thereby check rapid advance of the fungus from diseased to healthy trees. Other sanitary measures which apply for both the fungi will include removal of diseased and dead trees from plantations and burning them, digging out infected stumps and burning them before replanting a stand.

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EXPLANATION OF PLATES

PLATE I

FIG. 1.—A living tree of Casuarina showing infection of *Trichosporium vesiculosum* (marked by an arrow) beneath an wound caused by pruning of a branch (marked by a cross). The leader on the left was cut before taking the photograph (× 1/8).

FIG. 2.—A 1947 Casuarina plantation at Sondladoruvu in Sriharikota island showing a typical failed area. Note that the plants are stunted.

FIG. 3.—Healthy 1945 Casuarina plantation at Ponna in Sriharikota island. The plantation is situated along the coast of Bay of Bengal.

FIG. 4.—Blisters in the bark of Casuarina caused by *Trichosporium vesiculosum* (× 1/4).

FIG. 5.—A tree in the foreground on left with ruptured bark thrown out in form of scales and exposing black spore mass of *T. vesiculosum*.

FIG. 6.—A 1944 Casuarina plantation at Lalapet in the Padugais of Caveri. Many trees in this area are dead but a few show spores of *T. vesiculosum* under bark. A tree in the foreground shows infection by the fungus.

PLATE II

FIG. 7.—A different view of the 1944 Casuarina plantation at Lalapet along the river Caveri. Note the tall and healthy trees in the foreground, while those away from the Camera show dead tops.

FIG. 8.—A Casuarina with lateral roots exposed to show infection by *T. vesiculosum* (marked by arrows) both at the proximal and distal ends from the main stem (× 1/9).

FIG. 9.—Top layer of soil exposed to show shallow widespreading lateral roots in Casuarina. Note also the root fusion between lateral roots (marked by arrows) of two trees (× 1/6).

1

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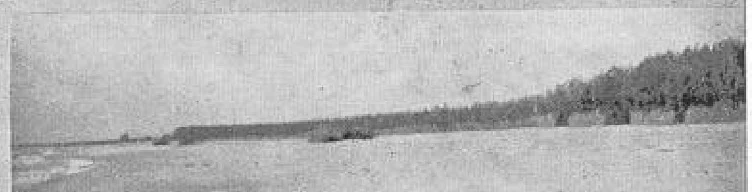

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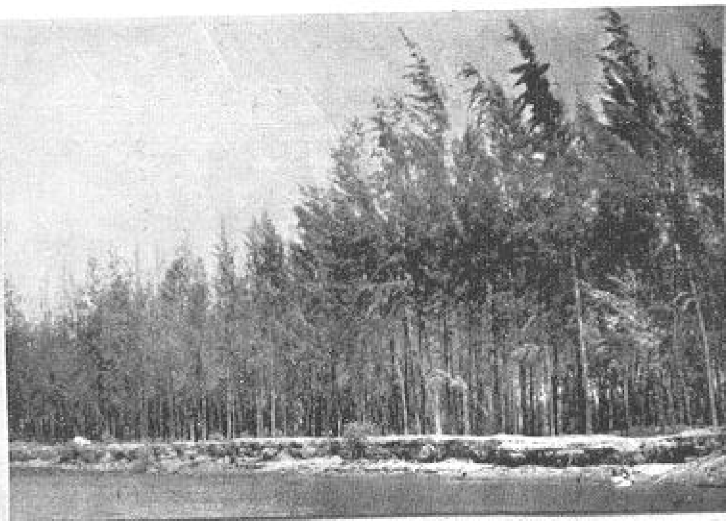

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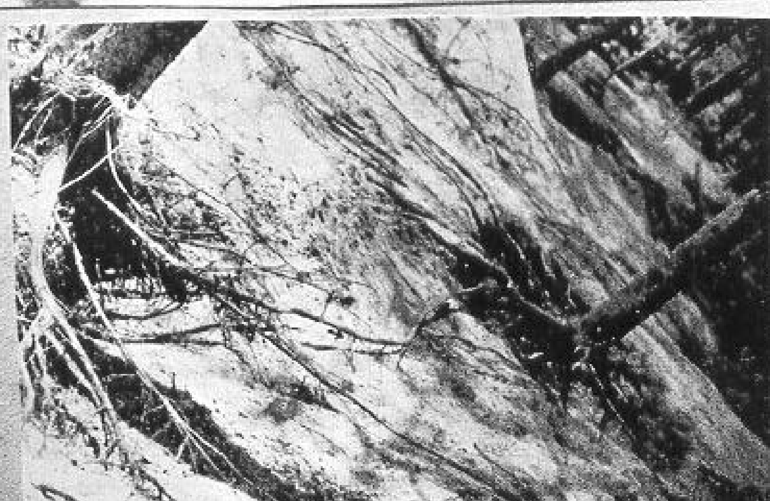

9

WEATHERING TRIALS ON AIRCRAFT WINGS

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(*Continued from* The Indian Forester, *April, 1951, page* 266)

The severity of the conditions for 15–6–1945 and 21–6–1945 as affected by location, etc., are given in Table IV where the areas under the temperature curves for temperatures above 60°C are taken.

TABLE IV

Area under the temperature curves for Mainplanes above 60°C

Mainplane	Location		Area-units 15–6–45	Area-units 21–6–45	Mainplane	Location		Area-units 15–6–45	Area-units 21–6–45
1	2		3	4	1	2		3	4
Anson Mainplane Port	L. 1	T.S.T.	27·8	10·0	Oxford Mainplane Starboard	Tip	T.S.T.	33·0	11·5
		T.S.	1·4	8·1		,,	T.S.	28·1	6·9
		Mdht.	0	0		,,	Mdht.	1·5	0
		B.S.	0	0		,,	B.S.	0	0
	L. 3	T.S.T.	26·8	0·2		Root	T.S.T.	34·4	11·9
		T.S.	24·6	0		,,	T.S.	29·2	8·9
		Mdht.	1·4	0		,,	Mdht.	3·4	0
		B.S.	0	0		,,	B.S.	0	0
	L. 4		18·6	0·2		Spar		7·7	0
	L. 4A		2·5	1·8		L.E.		27·7	9·7
	L. 9		14·8	1·0		Air		0	0
	Metal		18·7	3·8					
	Tank		12·0	1·7	Oxford Mainplane Port	Tip	T.S.T.	20·9	4·1
	L. 7		0	0		,,	T.S.	25·3	3·1
	Air		0	0		,,	Mdht.	2·5	0
	Spar	Top	14·7	1·7		,,	B.S.	0	0
	,,	Mdht.	0	0·2		Root	T.S.T.	23·7	0·7
	,,	B.S.	0	0		,,	T.S.	17·5	0·5
	L. 8	T.S.	34·1	2·2		,,	Mdht.	1·9	0
	,,	Mdht.	4·8	0·9		,,	B.S.	0	0
	,,	B.S.	0	0		Spar		17·1	0·5

(*contd.*)

TABLE IV—(*concld.*)

Mainplane	Location		Area-units	
			15–6–45	21–6–45
1	2		3	4
Oxford Mainplane Port	L.E.		0	0
	Air		0	0
Master Mainplane Port	Tip	Spar	..	3·1
	,,	T.S.T.	..	7·7
	,,	T.S.	..	9·2
	,,	B.S.	..	0
	Root	T.S.	..	4·3
	,,	Mdht.	..	0
	,,	B.S.	..	0
	Centre	T.S.	..	4·0
	,,	Mdht.	..	0
	,,	B.S.	..	0
Master Mainplane Starboard	Tip	Spar	14·4	0·4
	,,	T.S.T.	35·1	7·0
	,,	T.S.	32·8	7·0
	,,	B.S.	0	0
	Root	T.S.	20·0	2·1
	,,	Mdht.	4·4	0
	,,	B.S.	0	0
Master Mainplane Starboard	Centre	T.S.	27·5	4·9
	,,	Mdht.	0·5	0
	,,	B.S.	0	0
Mosquito Mainplane Starboard	L.E. Centre	T.S.T.	44·1	3·7
	,,	T.S.	39·4	2·9
	,,	Mdht.	11·6	0·4
	,,	B.S.	0·2	0
	L.E. Tip	T.S.T.	23·4	0·5
	,,	T.S.	18·7	0·1
	,,	B.S.	0	0
	Centre Mainplane	T.S.	22·6	0
		T.S.i	8·6	0
		Mdht.	0	0
		B.S.	0	0
	Centre Section	T.S.	34·9	0
		T.S.i	19·0	0
		Mdht.	0	0
		B.S.	0	0
	Spar	Spar	42·0	0
	L.E. Carriage	Mdht.	0	0
		Air	0	0

L.—Location.
T.S.T.—Top skin top.
T.S.—Top skin bottom.
Mdht.—Mid-height.
B.S.—Bottom skin top.
L.E.—Leading Edge.
T.S.i—Inner top skin.

Maximum temperature gradients between the top surface and bottom varied from 13°C to 34°C (Table II) depending on the locations and date. In the spar a temperature gradient of about 22°C was attained in May and 16°C in June.

In the *Master Port*, in June (14 days) the spar remained for a total of 29 hours over 60°C and for 5 hours over 70°C. Other parts of the top surface remained over 60°C for periods up to 42 hours and above 70° for periods up to 15 hours. Even the bottom surface attained a temperature of 60°C. In July (24 days) temperatures over 70°C were maintained for periods up to a total of about 19 hours. In September temperatures over 70°C were rare and in October temperatures over 70°C were not recorded. Temperatures over 60°C were

also recorded for shorter periods in the spar and the tip end. In Master Starboard similar behaviour was noticed and in September temperatures over 70°C were recorded for longer periods than in Master Port. In Master Port even at mid-height temperatures of over 60°C were noticed in June and July. The maximum gradients across top to bottom varied from 13 to 36°C.

In the *Oxford* temperatures over 70°C were maintained for periods up to 15 hours in May (6 days) and over 60°C up to 35 hours. Spar temperatures were over 70°C for 8 hours and over 60°C for over 27 hours. Bottom temperatures were over 60°C up to 3 hours. In June, top surfaces remained over 70°C for over 32 hours, and over 60°C for about 80 hours. Mid-height temperatures remained over 60°C for over 34 hours and the spar was above 70°C for over 8 hours and over 60°C for over 56 hours. Temperature gradients (maximum) from top to bottom varied from 11·5°C to 31°C.

In the *Mosquito Starboard* in May (3 days) the leading edge and the spar remained over 60°C for about 15 hours. In June (23 days) the leading edge remained over 60°C for 93 hours and over 70°C for 32 hours. The spar remained for 15 hours over 70°C and for 75 hours over 60°C. At the leading edge even at mid-height temperatures over 70°C were recorded for 4 hours. The centre section remained for 10 hours over 70°C. In July temperatures over 60°C and 70°C were recorded but for lesser periods. In August the same conditions were noticed, while in September temperatures over 70°C were rarely recorded. The spar attained 60°C for 10 hours. In October temperatures over 60°C were recorded in the leading edge and centre section but not in the spar. Maximum temperature gradients varied from 7°C to 26°C. The maximum drop was in the leading edge and centre section and lowest below the double skin.

From the above it will be seen that temperatures over 70°C are common for at least 5 months and over 60°C for at least 6 months in the year.

Some of the results obtained at Cochin were as follows.

Anson Starboard.—The temperature is highest on the top skin, next at mid-height and lowest on the bottom skin, except at location 5 where the mid-height temperature is lowest. The temperature rises to over 50°C at some points by 10 a.m. on clear days and remains above 50°C till about 5 p.m. The highest temperature recorded is about 75°C at location 1 top bottom at 12-00 noon on 1–10–1945 and at 11-45 a.m. on 9–11–1945. The difference in temperature between the top and bottom skins on the former occasion was 21·7°C at location 2 and 21·5°C at location 3, and on the latter occasion 15°C at location 2 and 12·5°C at location 3. Location 5 mid-height had the lowest temperature on either occasion and they were 43°C and 41°C respectively.

The temperature of the bottom surface of the top skin is often higher than the temperature of the top surface.

From 8 p.m. to 8 a.m. the temperature of the wing does not vary by more than 4°C from place to place or from the air temperature. The temperature is highest on the bottom skin, next at mid-height, then at the bottom surface of the top skin and lowest at the top surface of the top skin, except at location 5 where the mid-height temperature is lowest. The temperature of the wing is least between 5 and 8 a.m.

Anson Port.—The wing is in the east-west direction with the leading edge facing south. The temperature of the wing decreases in the order, top skin, mid-height, bottom skin, except at location 3 where the order is top skin, bottom skin, mid-height. The order is reversed at night. The maximum temperature recorded is 71·5°C at 1 p.m. on 26–9–1945 at location 1 top bottom.

The temperature of the bottom surface of the top skin is often higher than the temperature of the top surface.

From 8 p.m. to 8 a.m. the temperature of the wing does not vary by more than 4°C from place to place or from the air temperature. The temperature is lowest between 5 and 8 a.m.

Oxford Starboard and Port.—Both wings are in the east-west direction. The leading edge of the starboard wing faces north and that of the Port wing south.

The temperature falls in the order, top skin, mid-height, bottom skin. (The temperature of the bottom surface of the top skin is often higher than the temperature of the top surface). At night the order is reversed. The highest temperature recorded on the starboard is 70·75°C at tip top at 12-20 p.m. on 3–10–1945. The difference in temperature between top and bottom skins at that time was 17°C at root and 22°C at tip. For the Port the highest temperature is 73·5°C at leading edge top bottom at 1 p.m. on 3–10–1945, and the difference in temperature between top and bottom skins at root 14°C and at tip 25°C.

The temperatures of these wings also do not vary by more than 4°C from place to place or from the air temperature from 8 p.m. to 8 a.m. The lowest temperature is reached between 5 and 8 a.m.

Table V gives the maximum duration of temperatures above 60°C and 70°C.

TABLE V

Maximum duration of Temperatures above 60°C and 70°C in mainplanes at Cochin

Mainplane	Period of observation	Location	ABOVE 60°C		ABOVE 70°C	
			No. of days	Maximum duration and date	No. of days	Maximum duration and date
1	2	3	4	5	6	7
				h. m.		h. m.
Oxford Mainplane Port	24–5–1945 to 16–6–1945	L. 1	7	4 30 (28–5–45)	1	1 0 (26–5–45)
		L. 2	6	4 18 (28–5–45)	2	0 24 (26–5–45)
		L. 3	6	2 30 (28–5–45)	..	..
Oxford Mainplane Starboard	Do.	L. 1	6	3 5 (25–5–45)	..	..
		L. 2	6	5 30 (28–5–45)	2	3 5 (25–5–45)
		L. 3	6	4 25 (28–5–45)	..	..
Oxford Mainplane Port	27–9–1945 to 3–10–1945	L. 1	2	0 35 (3–10–45)	..	..
		L. 2	3	2 30 (1–10–45)	..	..
		L. 3	2	2 20 (3–10–45)	..	..

(*contd.*)

TABLE V—(*contd.*)

Mainplane	Period of observation	Location	Above 60°C		Above 70°C	
			No. of days	Maximum duration and date	No. of days	Maximum duration and date
1	2	3	4	5	6	7
				h. m.		h. m.
Oxford Mainplane Starboard	27-9-1945 to 3-10-1945	L. 1	5	2 45 (3-10-45)	..	..
		L. 2	2	1 50 (3-10-45)	..	..
		L. 3	2	2 30 (3-10-45)	..	..
Oxford Mainplane Port	4-10-1945 to 15-11-1945	L. 1	..	..	..	..
		L. 2	4	2 55 (5-10-45)	..	..
		L. 3	4	0 25 (5-10-45)	..	..
Oxford Mainplane Starboard	Do.	L. 1	6	2 30 (15-11-45)	..	..
		L. 2	4	1 55 (15-11-45)	..	..
		L. 3	4	1 45 (15-11-45)	..	..
Oxford Mainplane Port	20-4-1946 to 6-5-1946	L. 1	2	3 10 (24-4-46)	..	..
		L. 2	8	2 50 (24-4-46)	..	..
		L. 3	9	5 10 (24-4-46)	..	..
Oxford Mainplane Starboard	Do.	L. 1	2	0 50 (24-4-46)	..	..
		L. 2	6	3 50 (24-4-46)	..	..
		L. 3	4	2 40 (20-4-46)	..	..
Anson Port	27-9-1945 to 15-11-1945	L. 1	6	3 25 (5-10-45)	2	0 50 (3-10-45)
		L. 3	8	2 50 (30-9-45)	..	..
		L. 10	5	2 0 (3-10-45)	..	..

(*contd.*)

TABLE V—(*concld.*)

Mainplane	Period of observation	Location	ABOVE 60°C		ABOVE 70°C	
			No. of days	Maximum duration and date	No. of days	Maximum duration and date
1	2	3	4	5	6	7
				h. m.		h. m.
Anson Starboard	27-9-1945 to 15-11-1945	L. 1	11	5 20 (4-10-45)	2	0 40 (1-10-45)
		L. 3	5	2 5 (3-10-45)	..	..
		L. 10	7	1 55 (3-10-45)	..	..
Anson Port	20-4-1946 to 6-5-1946	L. 1	5	3 0 (24-4-46)	..	..
		L. 3	7	6 0 (20-4-46)	..	..
		L. 10	6	4 50 (24-4-46)	..	..
Anson Starboard	Do.	L. 1	10	5 20 (20-4-46)	2	0 30 (24-4-46)
		L. 3	8	4 10 (20-4-46)	1	0 10 (26-4-46)
		L. 10	5	4 40 (20-4-46)	..	..

Moisture.—The results on the variation of moisture content in the wings and air for veneers, spruce specimens and grids are shown in Table VI and **Figs. 36–79.**

TABLE VI

Moisture content of veneers, grids and spruce pieces

DEHRA DUN

Plane	Location	Date	MOISTURE CONTENT %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Anson Mainplane Port	I	30-8-45	..	13·75	..	..	..	..
		14-6-45	..	..	..	2·97	..	..
								10·78
	II	7-6-45	..	..	3·47	..	..	..
		30-8-45	15·60	..	..	..	..	..
							12·13	..

(*contd.*)

TABLE VI—(*contd.*)

Plane	Location	Date	Moisture Content %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Anson Mainplane Port	III	24–5–45	..	..	..	2·61	..	..
		4–10–45	..	17·84	..	..	..	..
		30–8–45	17·07	..	..	..	..	..
		14–6–45	..	..	2·29	..	14·78	15·23
	11	7–6–45	..	..	2·52	2·84	..	..
		30–8–45	17·21	..	..	..	..	..
		4–10–45	..	18·09	..	..	..	..
							14·69	15·25
Oxford Mainplane Port	Root	4–10–45	12·48	..	..	..	..	..
		31–1–46	..	14·81	..	..	..	..
		14–6–45	..	..	2·37	3·36	..	..
							10·11	11·45
	Tip	3–1–46	14·21	..	..	..	..	..
		14–6–45	..	..	2·82	..	..	..
							11·39	..
	Leading Edge	14–6–45	..	..	2·40	..	..	..
		30–8–45	13·10	..	..	..	..	..
							10·70	..
Oxford Mainplane Starboard	Root	27–9–45	13·41	14·36	..	..	..	..
		7–6–45	..	..	2·65	..	..	..
		31–5–45	..	..	..	1·04	..	..
							10·76	13·32
	Tip	14–6–45	..	..	1·95	..	..	..
		30–8–45	14·51	..	..	..	..	..
							12·56	..
	Leading Edge	14–6–45	..	..	2·39	..	..	..
		27–9–45	14·10	..	..	..	..	..
							11·71	..
Horsa Tailplane	East Wing Centre	27–9–45	19·32	..	..	..	..	..
		14–6–45	..	..	2·11	..	..	..
							17·21	..
	Fin	7–6–45	..	..	3·01	..	..	..
		26–7–45	13·16	..	..	..	..	..
							10·15	..
	West Wing Centre	7–6–45	..	..	1·96	..	..	..
		16–8–45	10·99	..	..	..	..	..
							9·03	..
	West Wing Tip	7–6–45	..	..	2·53	..	..	..
		30–8–45	13·20	..	..	..	..	..
							10·67	..

(*contd.*)

TABLE VI—(*contd.*)

Plane	Location	Date	Moisture Content %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Mosquito Starboard	Bulkhead Centre	27–9–45	..	13·62	..	..	..	..
		14–6–45	..	..	..	4·88	..	..
								8·74
	Root Centre	27–9–45	..	16·50	..	..	..	..
		14–6–45	..	..	..	4·11	..	..
							..	12·39
	Leading Edge Root	30–8–45	..	19·52	..	..	..	..
		14–6–45	..	..	..	3·62	..	..
							..	15·90
	Leading Edge Middle	27–9–45	..	17·44	..	..	..	..
		14–6–45	..	..	..	2·99	..	..
							..	14·45
Mosquito Main-plane Port	Bulkhead Centre	30–8–45	13·82	..	..	..	..	..
		14–6–45	..	..	3·98	..	..	..
							9·84	..
	Bulkhead Trailing Edge	14–6–45	..	..	2·97	..	..	..
		30–8–45	16·50	..	..	..	..	..
							13·53	..
	Root Centre	30–8–45	13·39	..	..	..	..	..
		14–6–45	..	..	3·59	..	..	..
							9·80	..
	Leading Edge Centre	27–9–45	20·70	..	..	..	..	..
		14–6–45	..	..	2·14	..	..	..
							18·56	..
	Leading Edge Middle	30–8–45	19·44	..	..	..	..	..
		14–6–45	..	..	2·32	..	..	..
							17·12	..
Master Mainplane Port	..	30–8–45	12·78	..	..	..	..	..
		14–6–45	..	..	3·02	..	..	..
							9·76	..
Master Mainplane Starboard	..	30–8–45	18·16	..	..	..	..	..
		14–6–45	..	..	2·68	..	..	..
							15·48	..
	Air	14–6–45	..	..	6·06	6·78	..	..
		30–8–45	20·26	19·37	..	..	..	..
							14·20	12·59
			COCHIN 25–5–1945 to 16–6–1945					
Oxford Mainplane Starboard	Root	24–5–45	..	..	10·3	10·6	..	..
		15–6–45	14·6	..	..	..	..	..
		7–6–45	..	13·8	..	..	..	..
							4·3	3·2

(*contd.*)

TABLE VI—(*contd.*)

Plane	Location	Date	Moisture Content %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Oxford Mainplane Port	Root	24–5–45	..	..	10·3	10·6	..	..
		15–6–45	13·9	..	..	..	..	..
		7–6–45	..	14·3	..	..	..	..
							3·6	3·7
		18–9–1945 to 16–11–1945						
Anson Mainplane Starboard	1	16–11–45	..	13·14	..	..	..	..
		7–11–45	..	..	..	9·86	..	..
								3·28
	2	16–11–45	15·22	..	..	..	..	..
		6–10–45	..	..	10·23	..	..	..
							4·99	..
	3	29–9–45	12·80	13·37	..	..	..	..
		7–9–45	..	..	10·17	..	..	..
		6–10–45	..	..	..	10·56	..	..
							2·63	2·81
	4	14–11–45	14·42	..	..	..	..	..
		6–10–45	..	..	11·51	..	..	..
							2·91	..
	5	14–11–45	12·18	13·67	..	..	..	..
		7–11–45	..	..	10·92	..	..	..
		6–10–45	..	..	..	12·45	..	..
							1·26	1·22
	11	7–11–45	14·73	..	..	..	..	..
		6–10–45	..	..	12·54	13·35	..	..
		14–11–45	..	17·16	..	..	..	..
							2·19	3·81
Anson Mainplane Port	3	14–11–45	..	16·92	..	..	..	..
		6–10–45	..	..	..	10·96	..	..
							..	5·96
	5	6–10–45	..	..	..	13·10	..	..
		14–11–45	..	14·26	..	..	..	..
								1·16
	11	16–11–45	..	11·54	..	..	..	..
		6–10–45	..	..	..	9·66	..	..
								1·88
Oxford Mainplane Starboard	Root	29–9–45	11·94	11·90	..	..	..	..
		7–11–45	..	..	9·14	10·21	..	..
							2·80	1·69
	Root Leading Edge	6–10–45	10·50	..	..	..	..	..
		16–11–45	..	..	8·25	..	..	..
							2·25	..
	Tip	14–11–45	12·50	..	..	..	..	..
		25–9–45	..	..	8·05	..	..	..
							4·45	..

(contd.)

TABLE VI—(*contd.*)

Plane	Location	Date	Moisture Content %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Oxford Mainplane Port	Root.	29–9–45	11·91	11·90	..	..	..	..
		7–11–45	..	..	10·01	10·87	..	..
							1·90	1·03
	Root Leading Edge	18–9–45	..	..	8·69	..	..	..
		6–10–45	10·87	..	..	..	..	..
							2·18	..
	Tip	18–9–45	..	..	9·75	..	..	..
		16–11–45	12·56	..	..	..	..	..
							2·81	..
	Air	29–9–45	14·89	15·94	..	..	..	..
		7–11–45	..	..	..	14·66	..	..
		16–11–45	..	..	12·48	..	..	..
							2·41	1·28
		17–4–1946 to 6–5–1946						
Oxford Mainplane Starboard	Root	2–5–46	8·77	8·62	..	..	..	..
		25–4–46	..	..	..	8·35	..	..
		6–5–46	..	..	8·19	..	..	..
							0·58	0·27
	Tip	2–5–46	8·19	..	..	..	..	..
		6–5–46	..	..	7·77	..	..	..
							0·42	..
	Leading Edge	2–5–46	8·53	..	..	..	..	..
		6–5–46	..	..	7·67	..	..	..
							0·86	..
Oxford Mainplane Port	Root	25–4–46	7·89	..	..	8·33	..	..
		2–5–46	..	8·55	7·63	..	..	..
							0·26	0·22
	Leading Edge	6–5–46	8·26	..	..	..	..	..
		2–5–46	..	..	7·74	..	..	..
							0·52	..
	Air	6–5–46	12·84	11·53	..	..	..	..
		2–5–46	..	..	12·47	..	..	..
		25–4–46	..	..	..	11·16	..	..
							0·37	0·37
Anson Mainplane Starboard	1	2–5–46	..	8·01	..	..	..	..
		25–4–46	..	..	..	7·38	..	..
							..	0·63
	2	2–5–46	7·95	..	..	..	..	..
		25–4–46	..	..	7·47	..	..	..
							0·48	..
	3	2–5–46	7·69	8·07	..	..	..	..
		25–4–46	..	..	7·14	7·63	..	..
							0·55	0·44

(*contd.*)

TABLE VI—(*contd.*)

Plane	Location	Date	Moisture Content %					
			Maximum		Minimum		Difference	
			Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8	9
Anson Mainplane Starboard	4	6–5–46	7·30	..	..	..	..	..
		25–4–46	..	..	6·98	..	..	..
							0·32	..
	5	2–5–46	8·69	9·47	..	..	..	..
		25–4–46	..	..	8·35	8·75	..	..
							0·34	0·72
	11	2–5–46	8·35	8·12	..	..	..	..
		25–4–46	..	..	8·11	7·66	..	..
							0·24	0·46
Anson Mainplane Port	1	2–5–46	..	8·89	..	..	..	..
		6–5–46	..	..	..	8·14	..	..
								0·75
	3	2–5–46	..	8·20	..	..	..	..
		25–4–46	..	..	..	7·61	..	..
								0·41
	5	2–5–46	..	8·89	..	..	..	..
		25–4–46	..	..	..	8·46	..	..
								0·43
	11	2–5–46	..	7·70	..	..	..	..
		25–4–46	..	..	..	7·18	..	..
								0·52

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content %				
			Maximum		Minimum		Difference
			Time	Moisture	Time	Moisture	Moisture
1	2	3	4	5	6	7	8
Mosquito Mainplane Starboard	Bulkhead	17–7–45	7·30	15·08	..	..	..
		11–6–45	..	..	11·30	0·46	..
							14·62
	Root end Centre	27–8–45	11·30	19·27	..	..	..
		11–6–45	..	..	11·30	0·13	..
							19·14
	Leading Edge Root end	15–6–45	..	..	11·30	0·98	..
		27–8–45	11·30	18·00	..	..	..
							17·02
	Leading Edge Middle	11–6–45	..	..	11·30	0·00	..
		2–10–45	11·30	16·98	..	..	..
							16·98

(*contd.*)

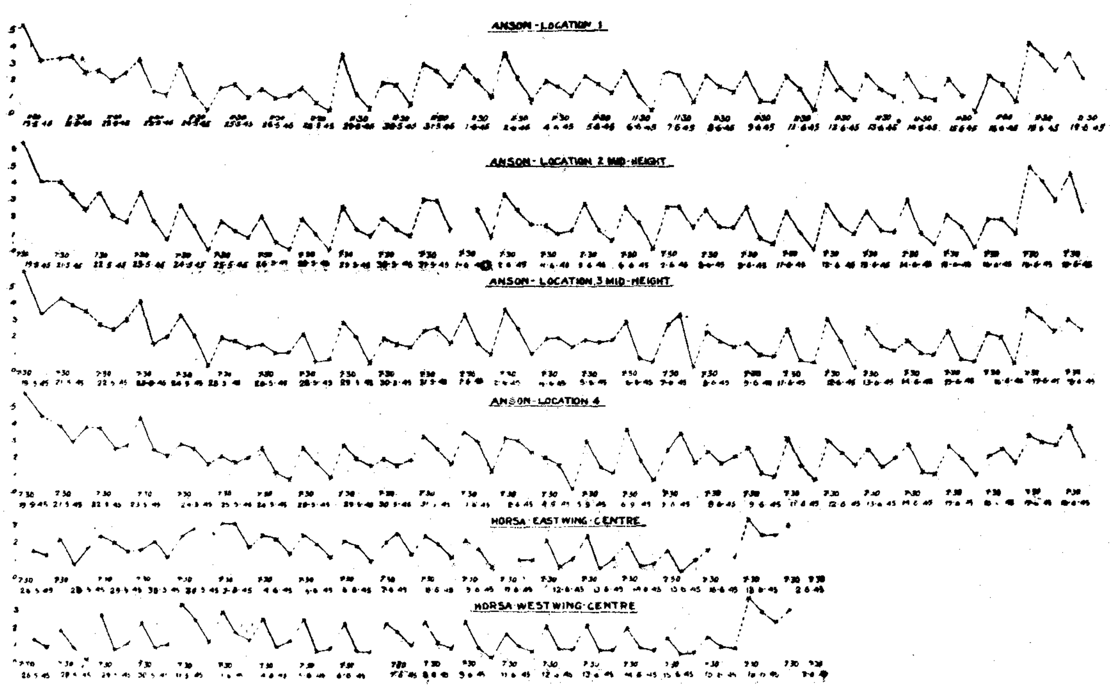

FIG. 36.—Variation of moisture content of veneers in Anson Mainplane at Dehra Dun 19-5-1945 to 19-6-1945. Also in Horsa Tailplane from 19-5-1945 to 2-6-1945.

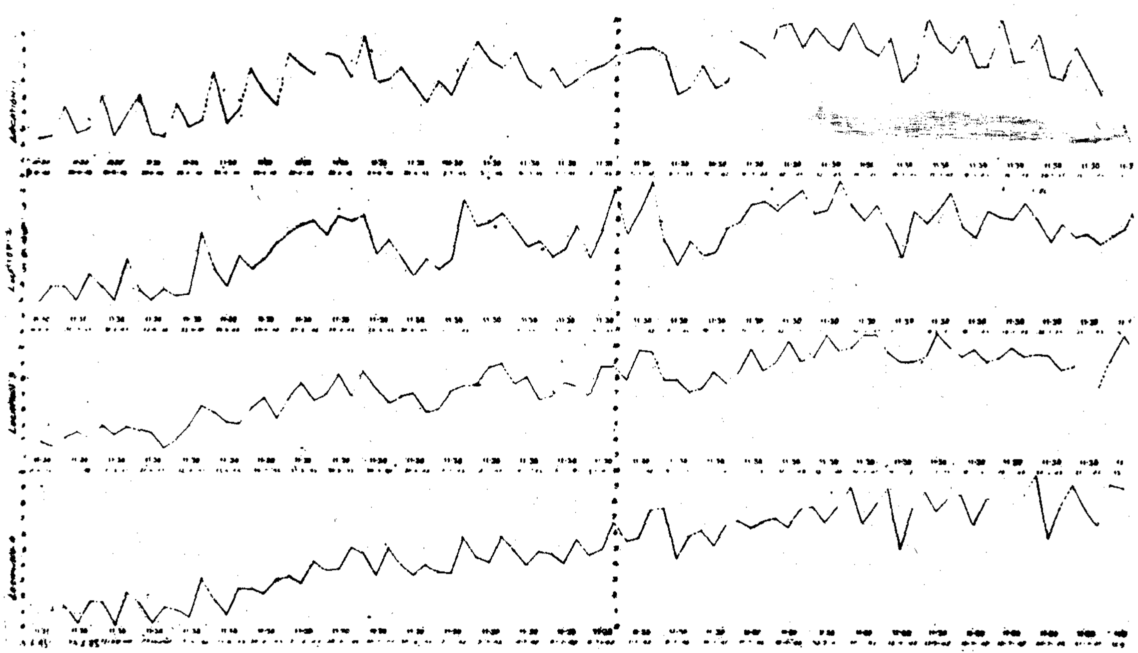

FIG. 37.—Variation of moisture content of veneers in Anson Mainplane at Dehra Dun 19-6-1945 to 24-7-1945.

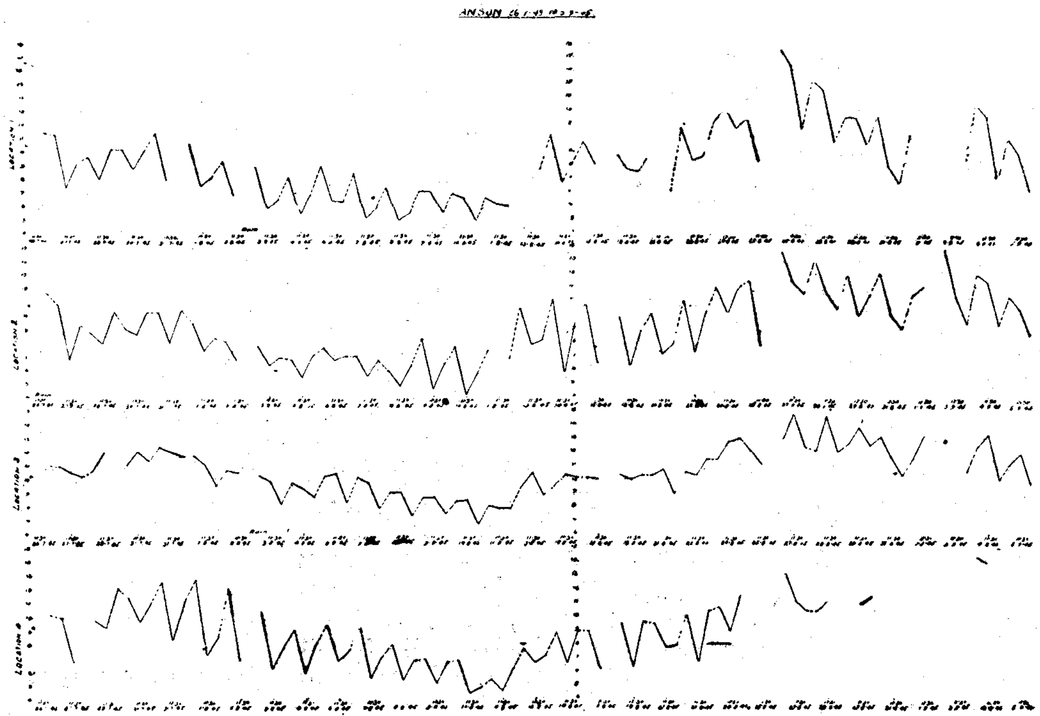

FIG. 38.—Variation of moisture content of veneers in Anson Mainplane at Dehra Dun 26-7-1945 to 5-9-1945.

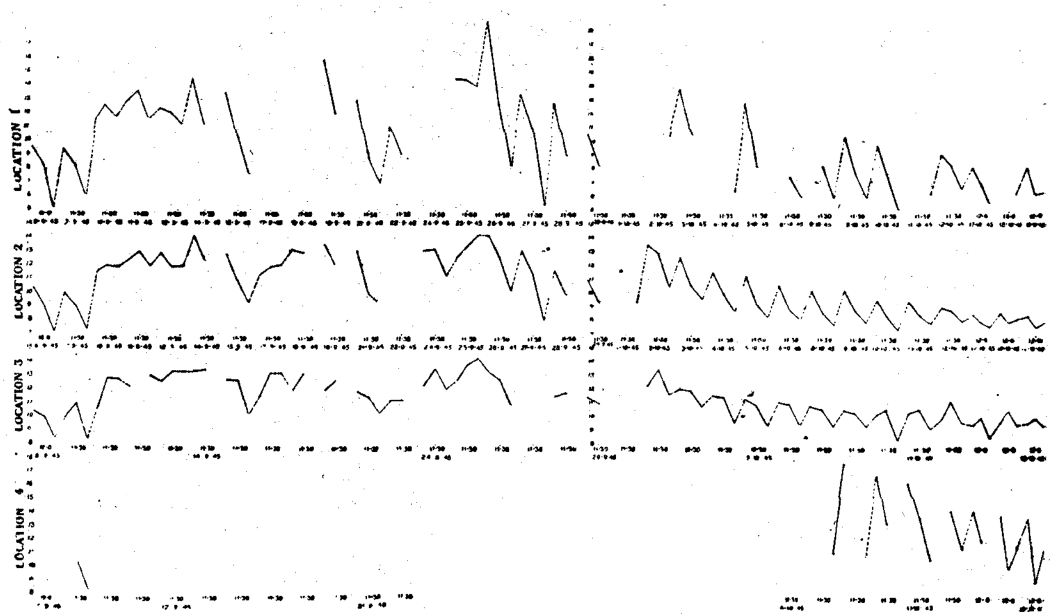

FIG. 39.—Variation of moisture content of veneers in Anson Mainplane at Dehra Dun 6-9-1945 to 19-10-1945.

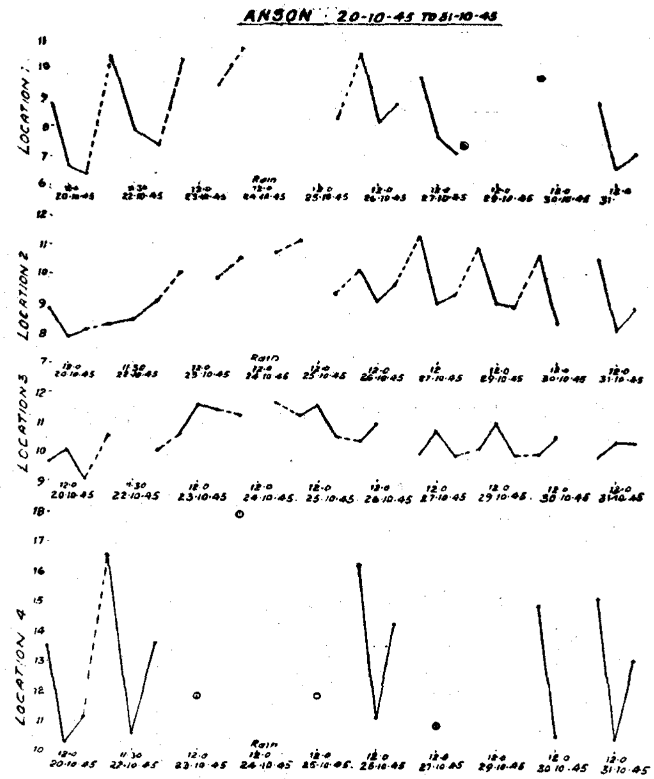

FIG. 40.—Variation of moisture content of veneers in Anson Mainplane at Dehra Dun 20-10-1945 to 31-10-1945.

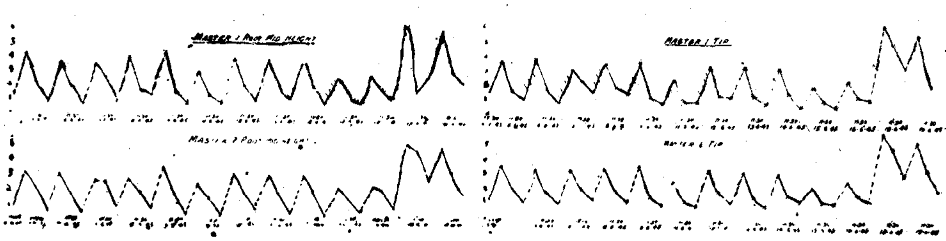

FIG. 41.—Variation of moisture content of veneers in Master Mainplanes 4-6-1945 to 19-6-1945.

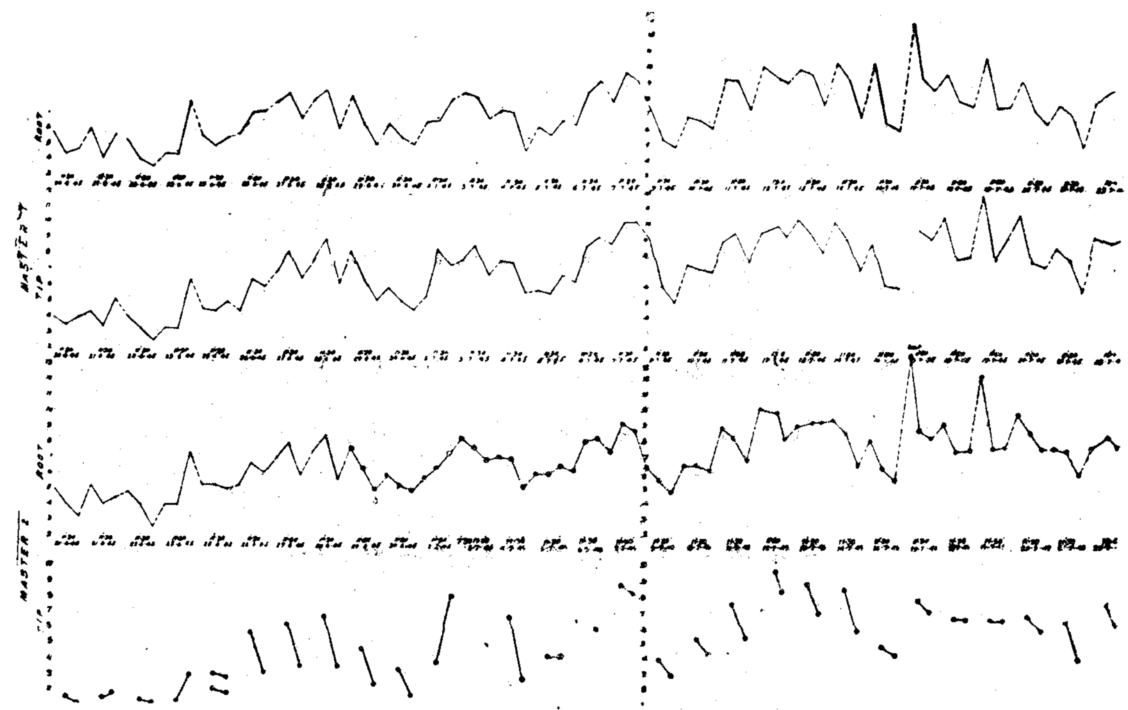

FIG. 42.—Variation of moisture content of veneers in Master Mainplanes 20-6-1945 to 25-7-1945.

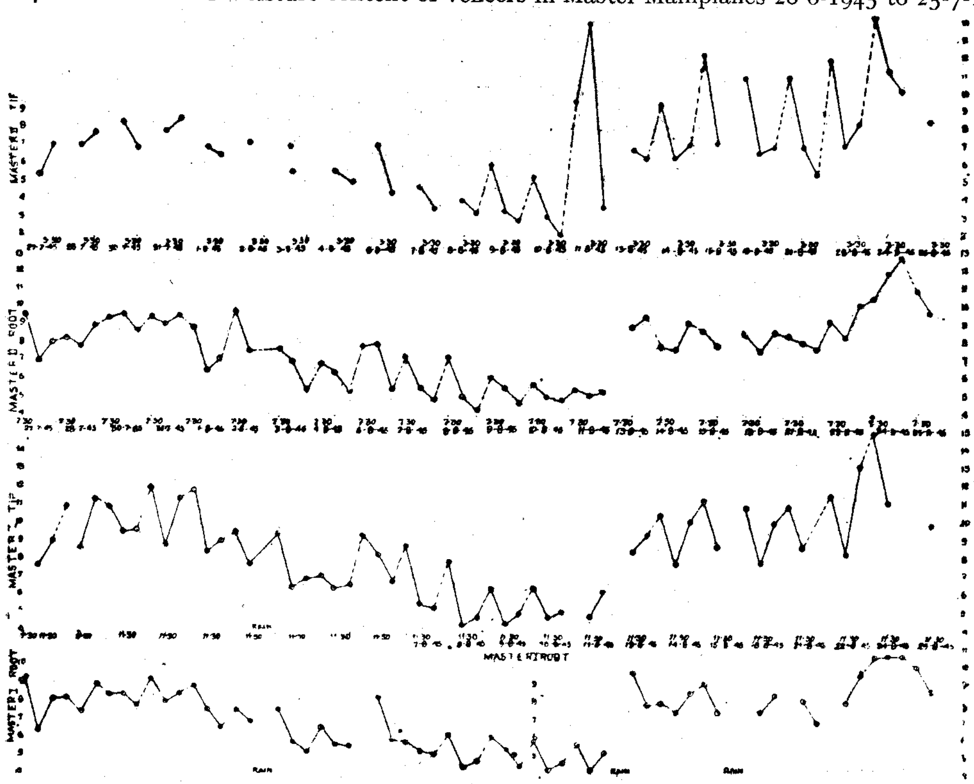

FIG. 43.—Variation of moisture content of veneers in Master Mainplanes 27-7-1945 to 25-8-1945.

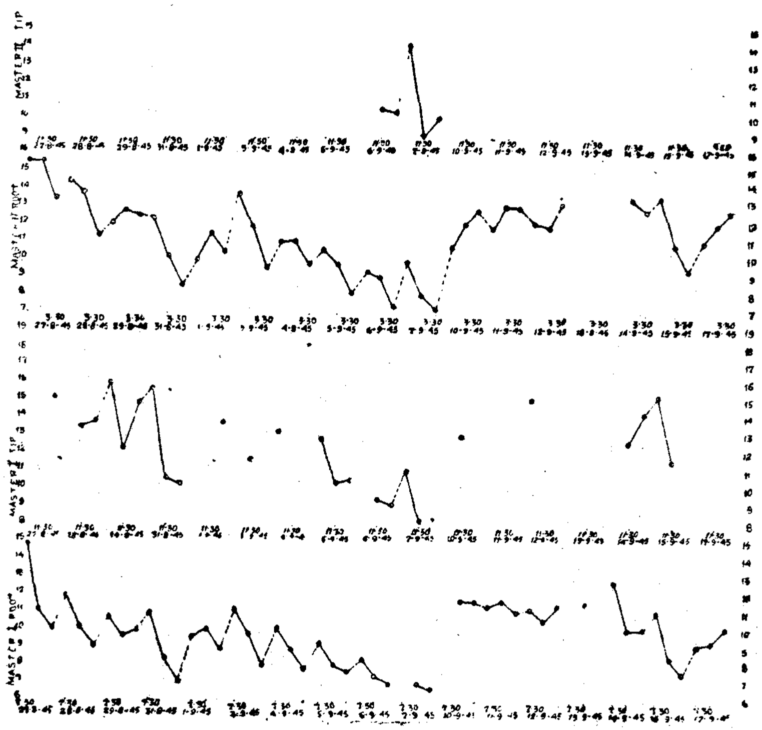

FIG. 44.—Variation of moisture content of veneers in Master Mainplane 27-8-1945 to 17-9-1945.

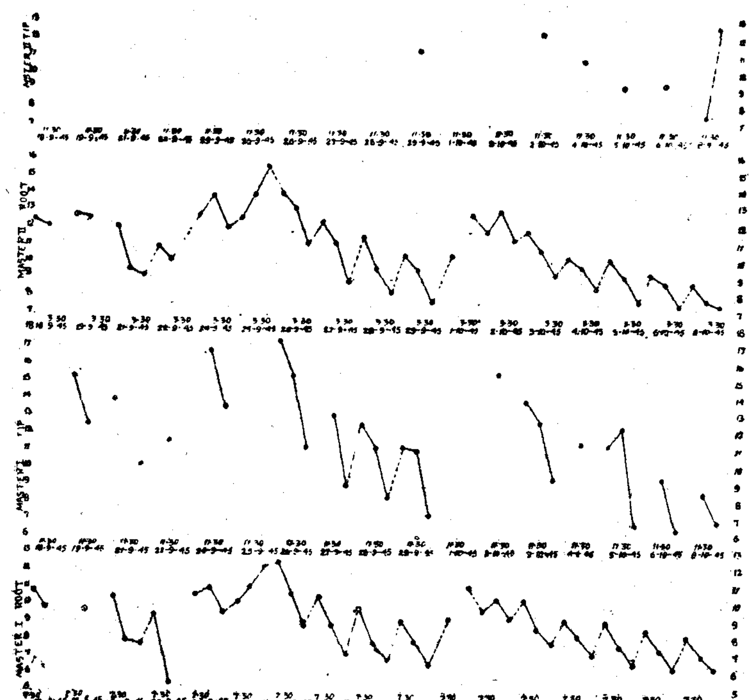

FIG. 45.—Variation of moisture content of veneers in Master Mainplane 18-9-1945 to 8-10-1945.

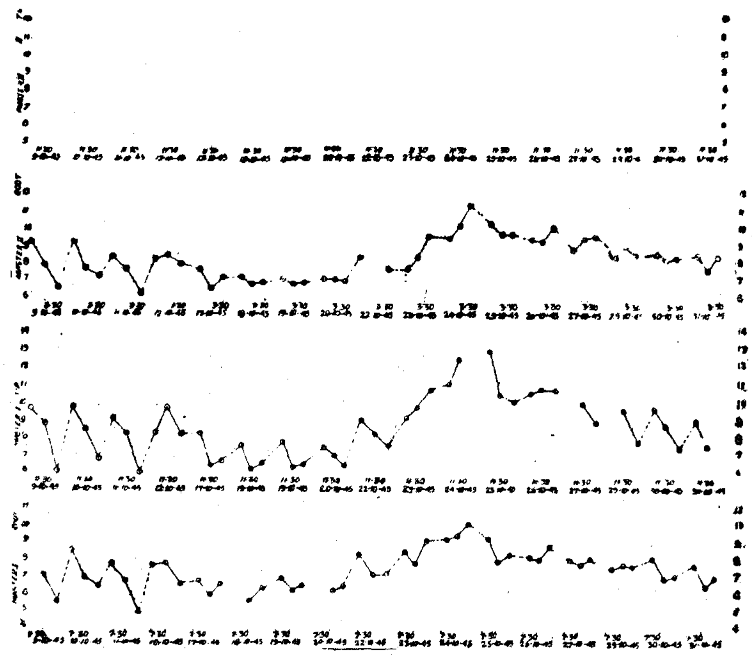

FIG. 46.—Variation of moisture content of veneers in Master Mainplane 9-10-1945 to 31-10-1945.

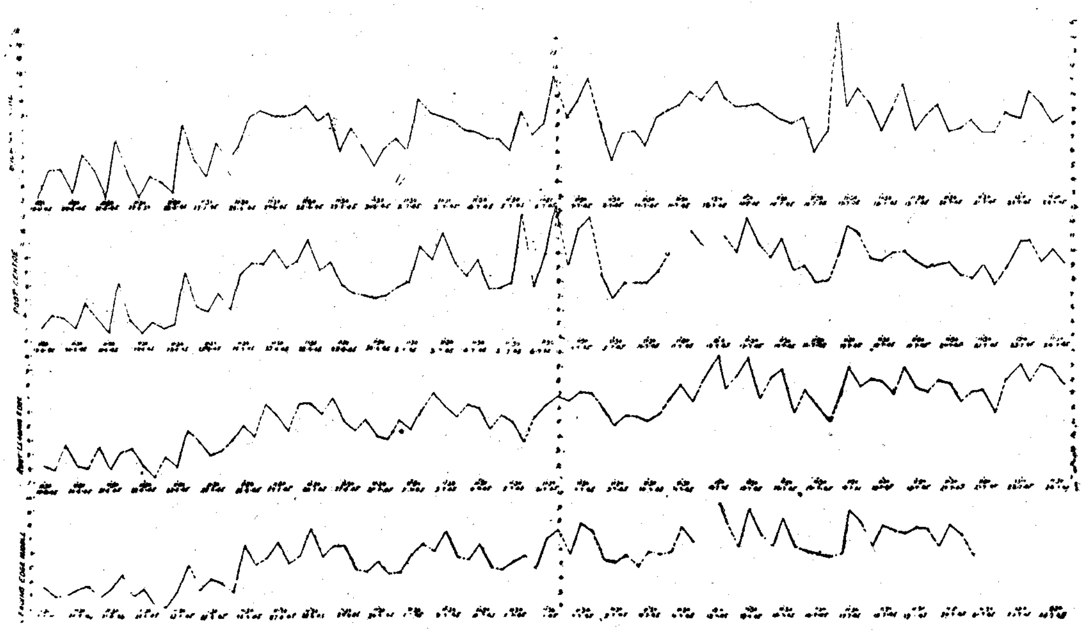

FIG. 47.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 19-6-1945 to 24-7-1945.

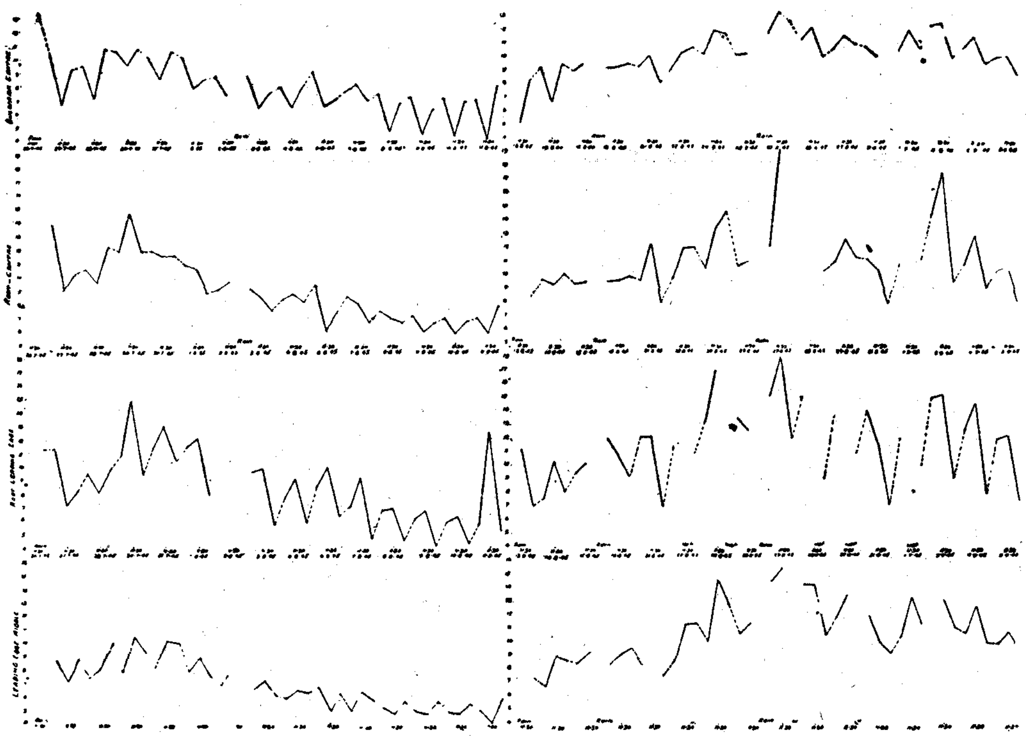

FIG. 48.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 26-7-1945 to 5-9-1945.

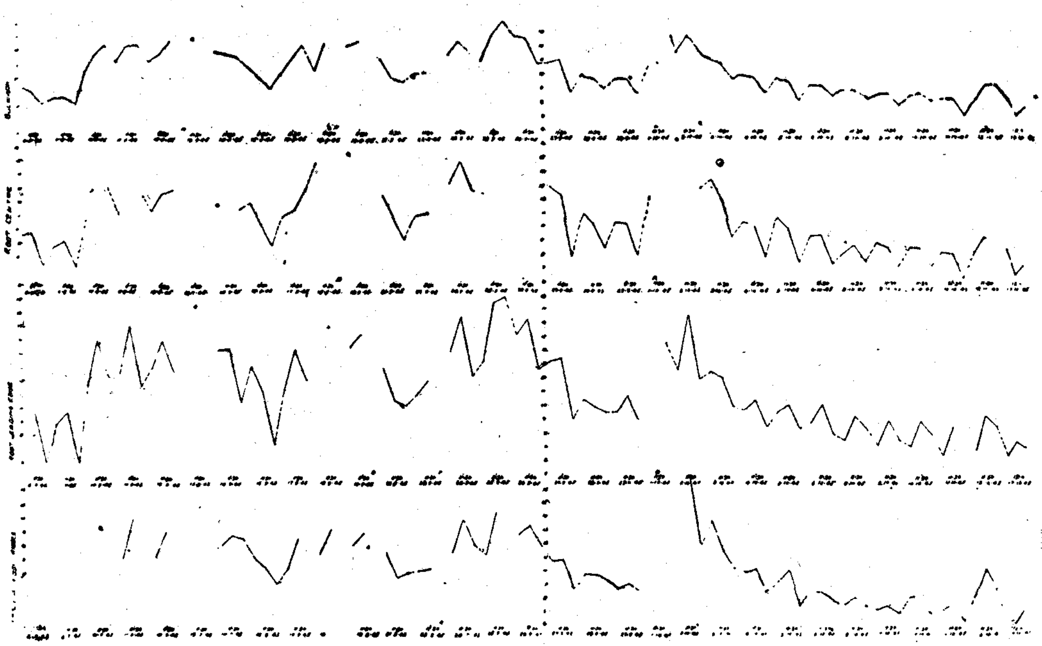

FIG. 49.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 6-9-1945 to 17-10-1945.

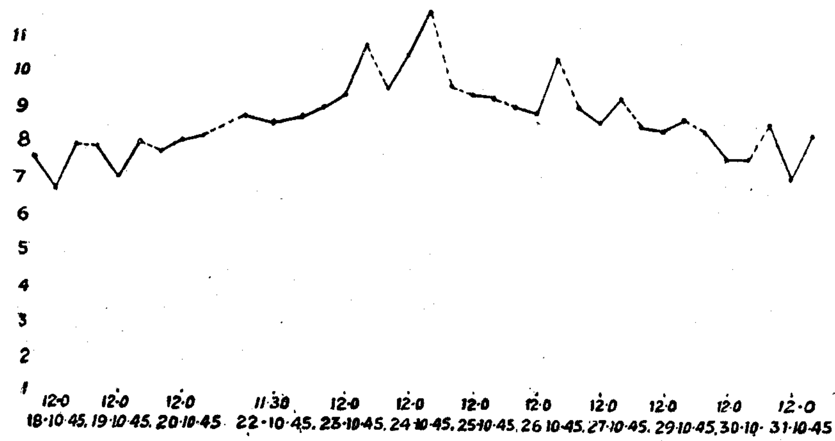

FIG. 50.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 18-10-1945 to 31-10-1945.

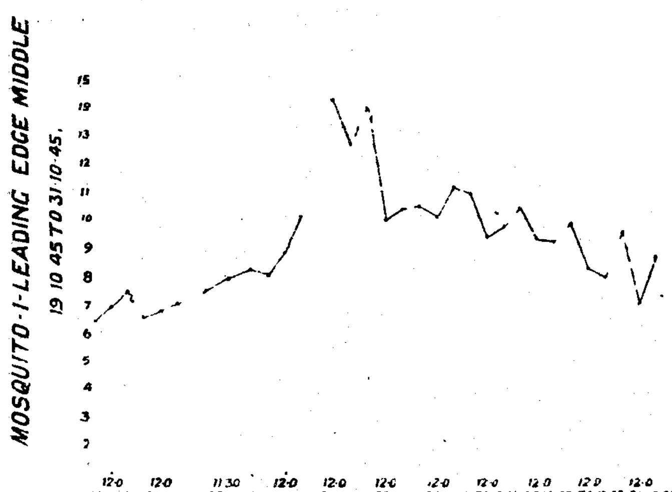

FIG. 51.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 19-10-1945 to 31-10-1945.

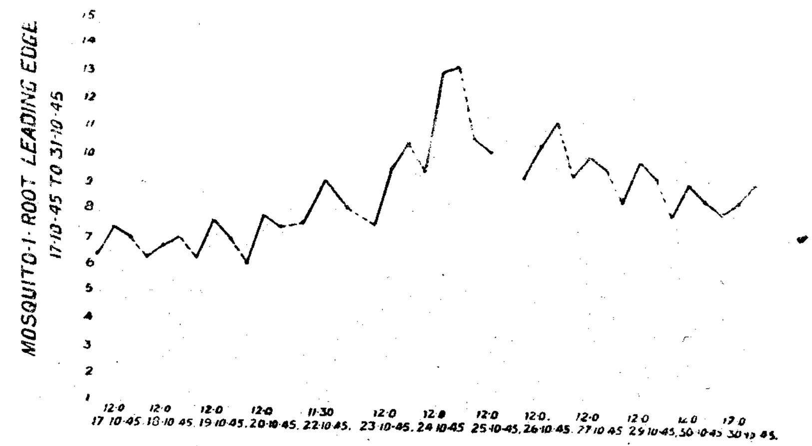

FIG. 52.—Variation of moisture content of veneers in Mosquito Mainplane Starboard 17-10-1945 to 31-10-1945.

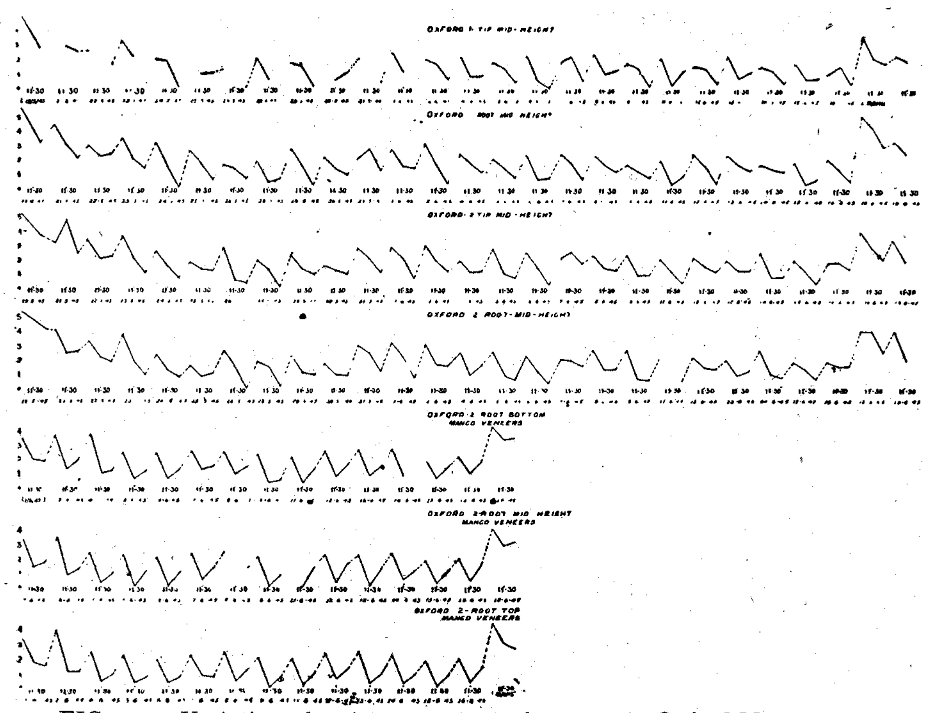

FIG. 53.—Variation of moisture content of veneers in Oxford Mainplanes.

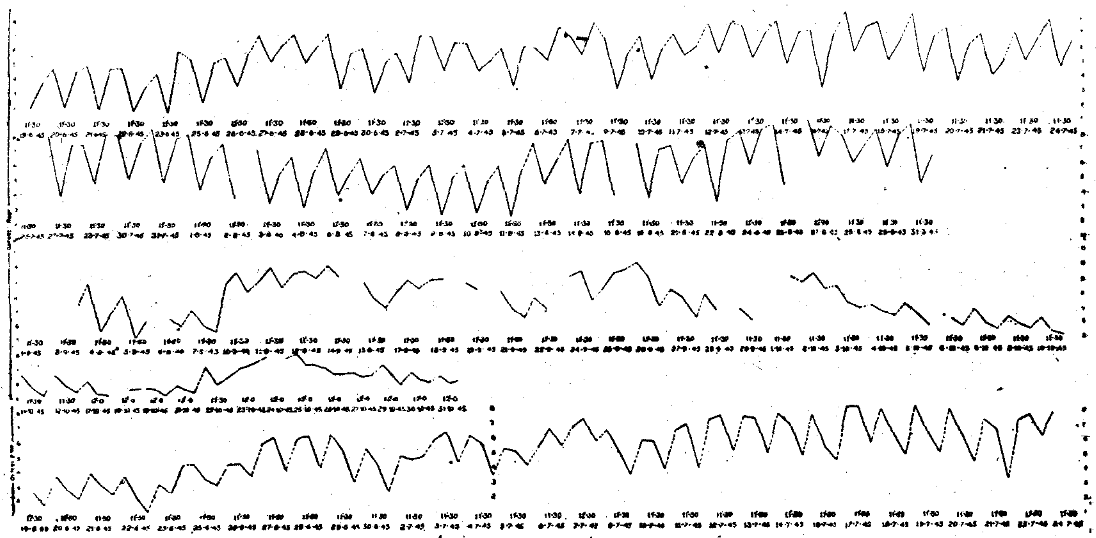

FIG. 54.—Variation of moisture content of veneers in Oxford Mainplanes.

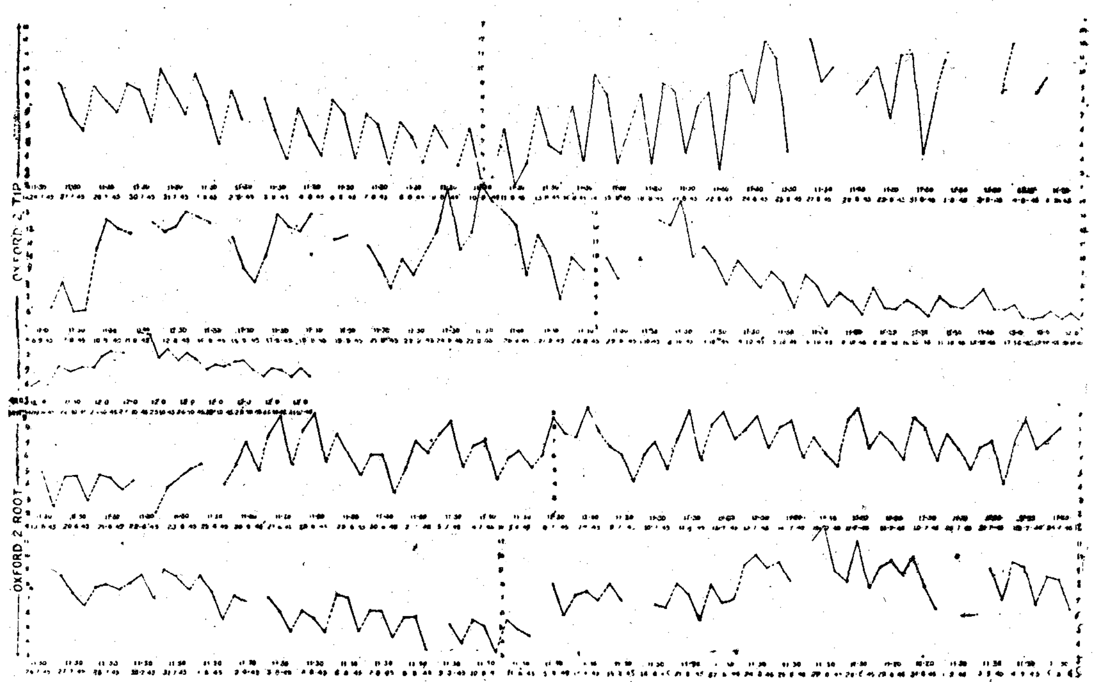

FIG. 55.—Variation of moisture content of veneers in Oxford Mainplanes.

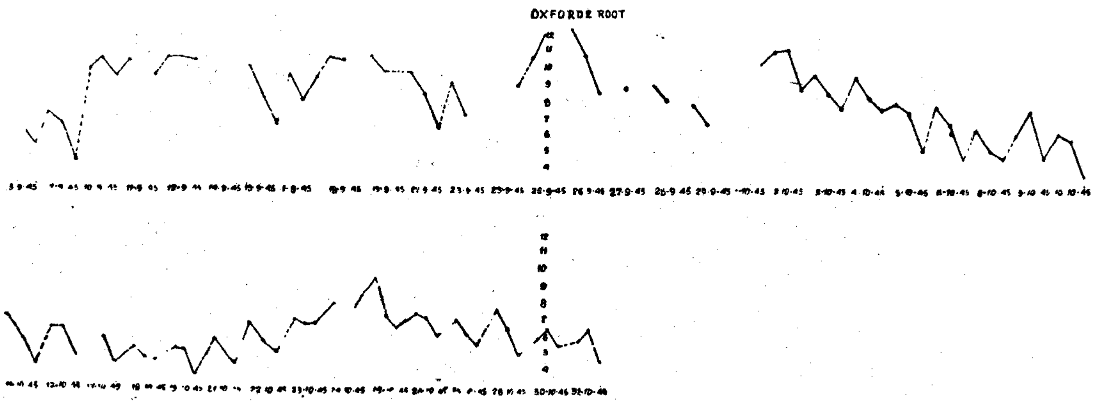

FIG. 56.—Variation of moisture content of veneers in Oxford Mainplanes.

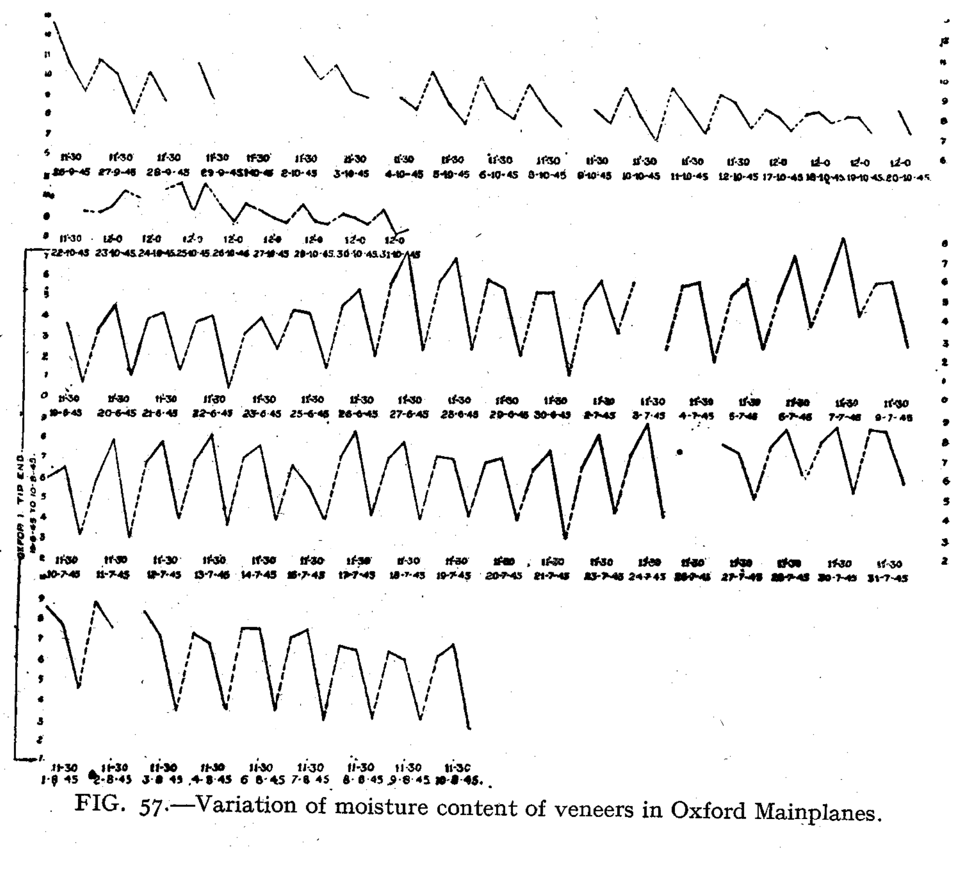

FIG. 57.—Variation of moisture content of veneers in Oxford Mainplanes.

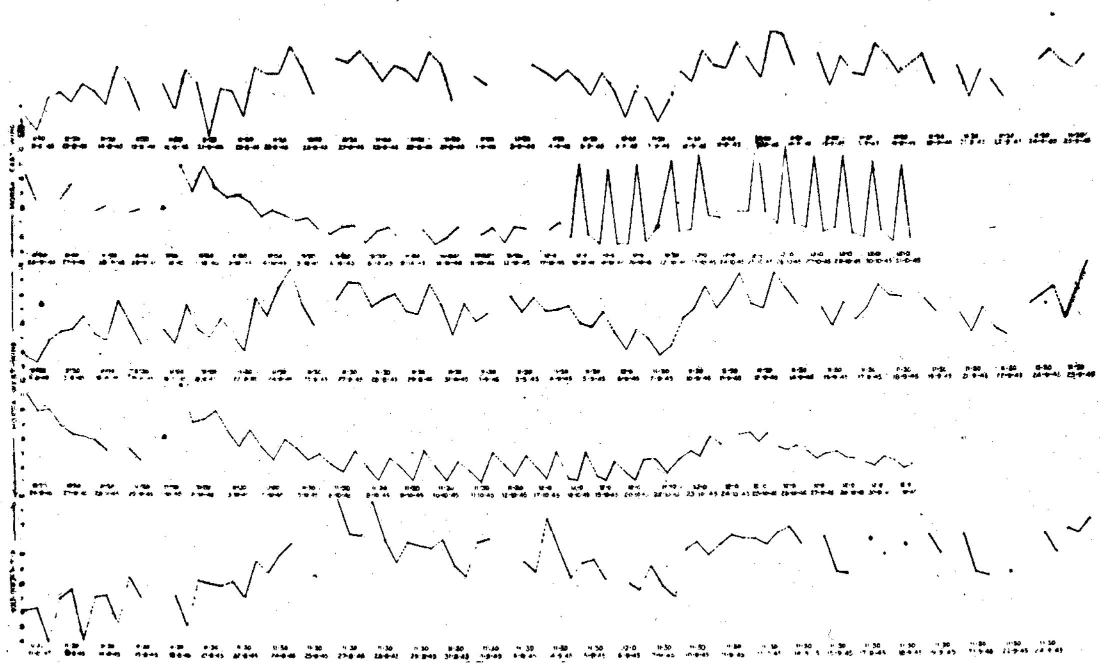

FIG. 58.—Variation of moisture content of veneers at Oxford Mainplane Starboard tip (11-8-1945 to 31-10-1945) and in Horsa Tailplane (West Wing 11-8-1945 to 31-10-1945 and East Wing 11-8-1945 to 25-9-1945).

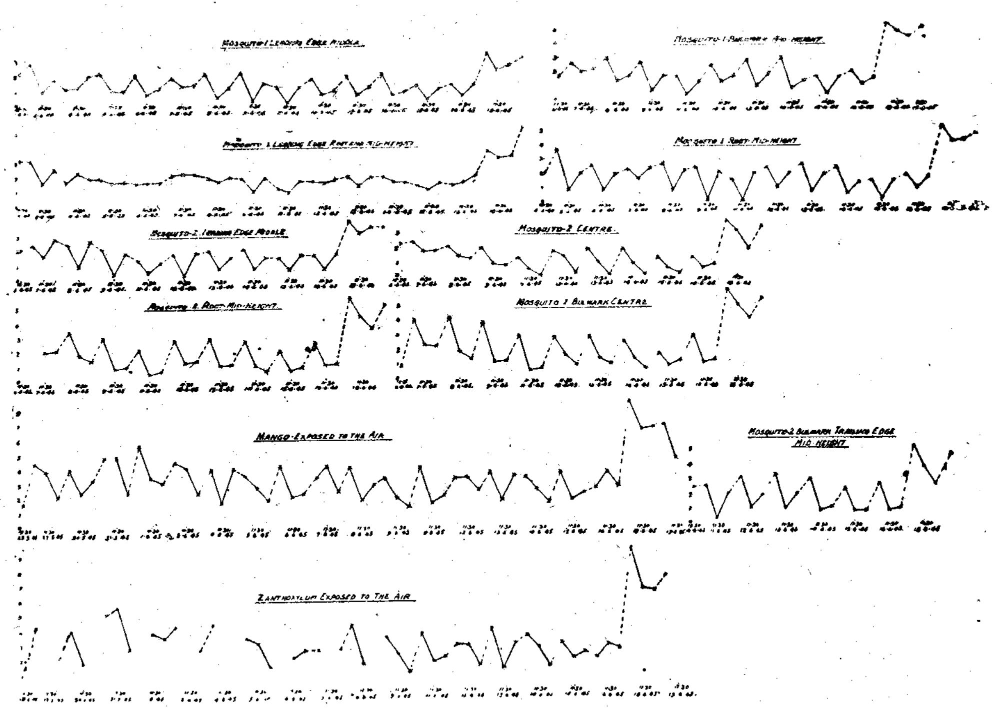

FIG. 59.—Variation of moisture content of veneers exposed to air 28-5-1945 to 19-6-1945. Also of veneers in Mosquito Mainplanes.

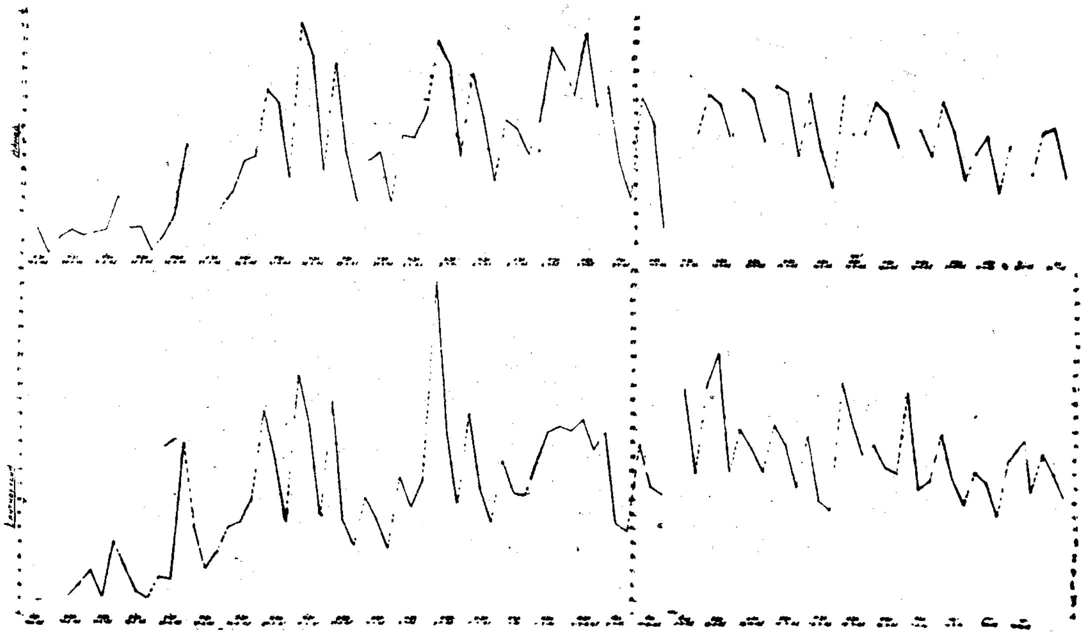

FIG. 60.—Variation of moisture content of veneers exposed to air 19-6-1945 to 24-7-1945.

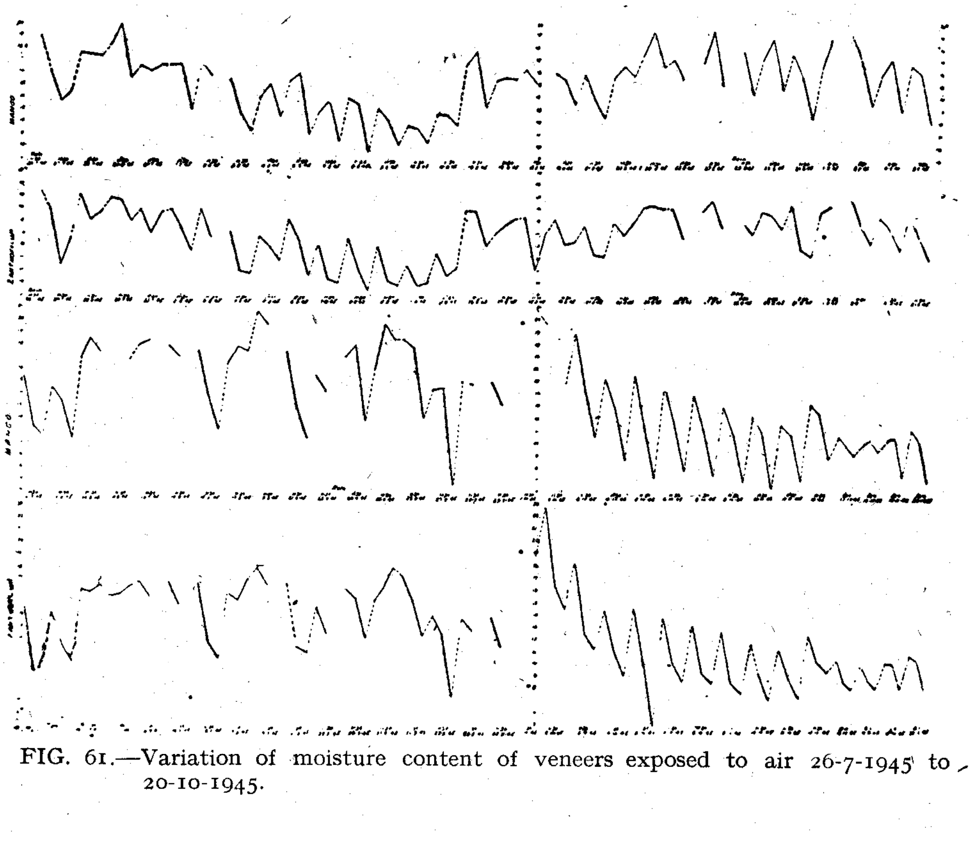

FIG. 61.—Variation of moisture content of veneers exposed to air 26-7-1945 to 20-10-1945.

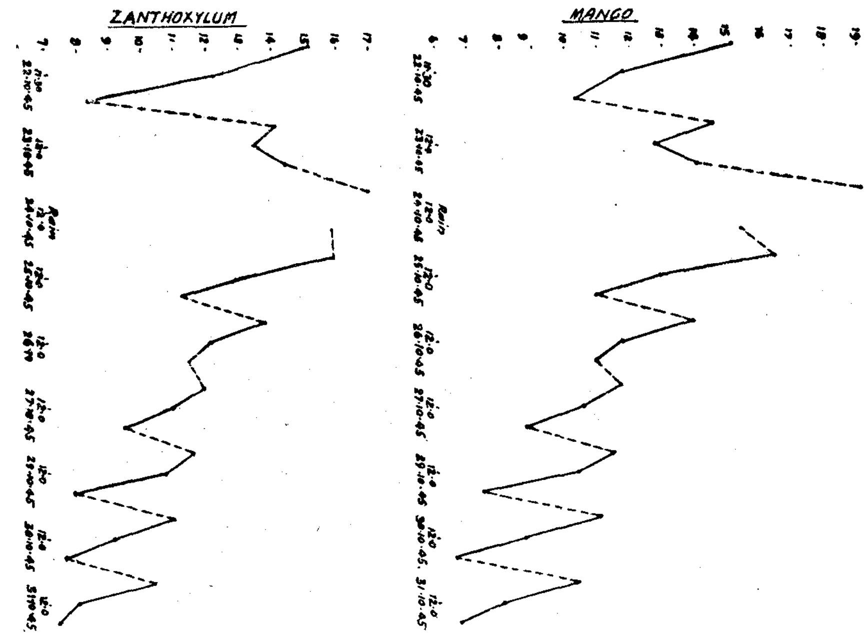

FIG. 62.—Variation of moisture content of veneers exposed to air 22-10-1945 to 31-10-1945.

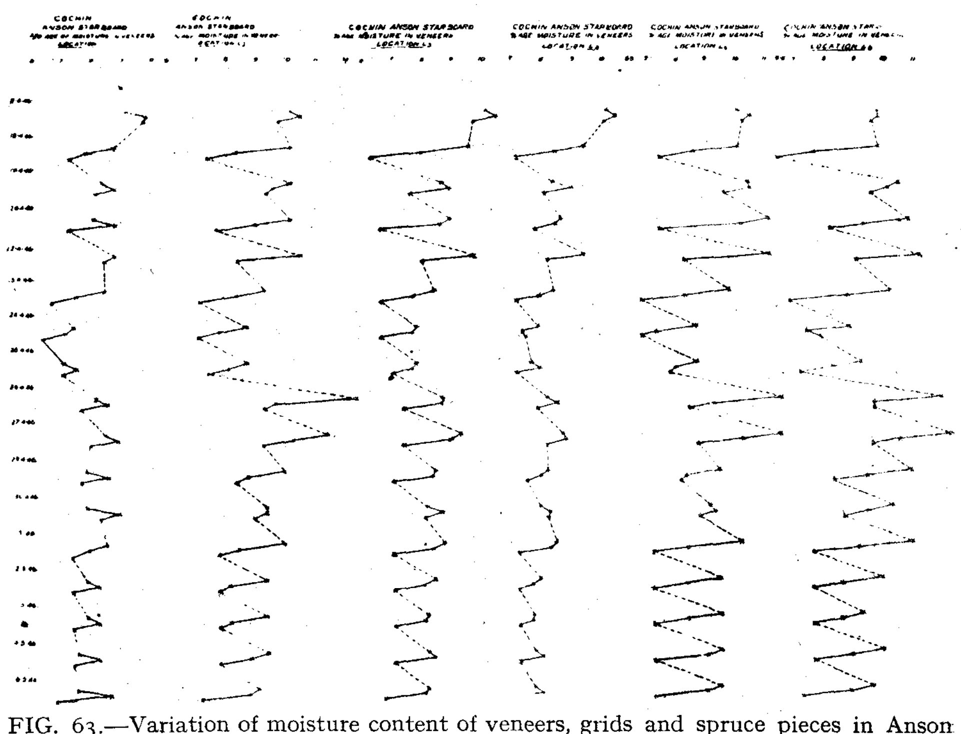

FIG. 63.—Variation of moisture content of veneers, grids and spruce pieces in Anson and Oxford Mainplanes at Cochin 17-4-1946 to 6-5-1946.

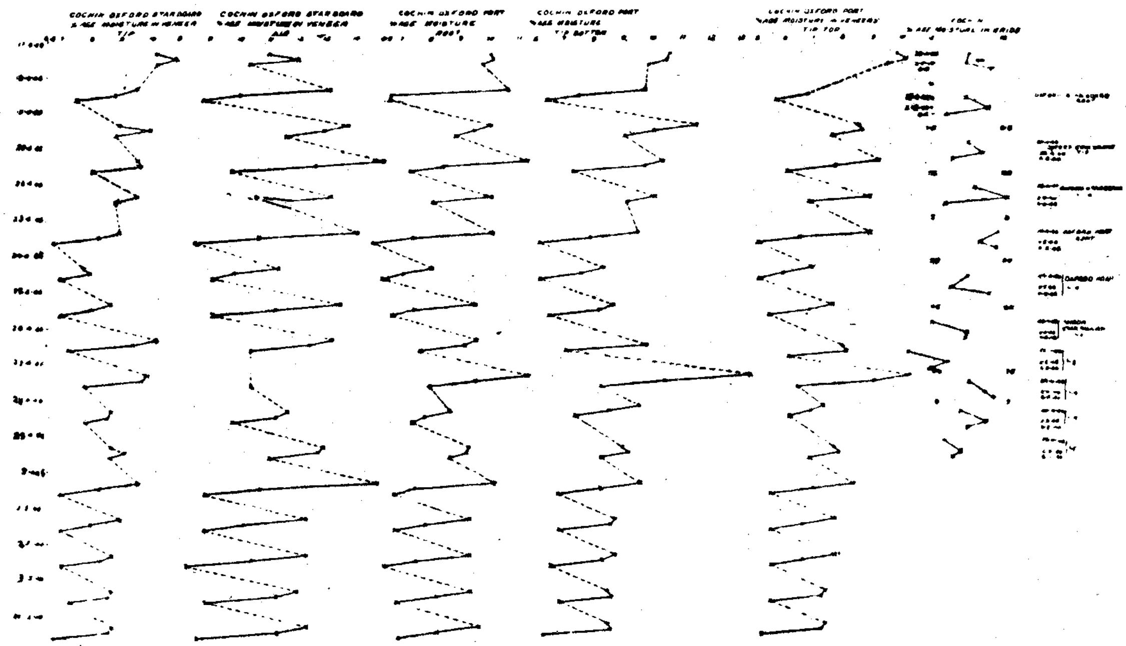

FIG. 64.—Variation of moisture content of veneers, grids and spruce pieces in Anson and Oxford Mainplanes at Cochin.

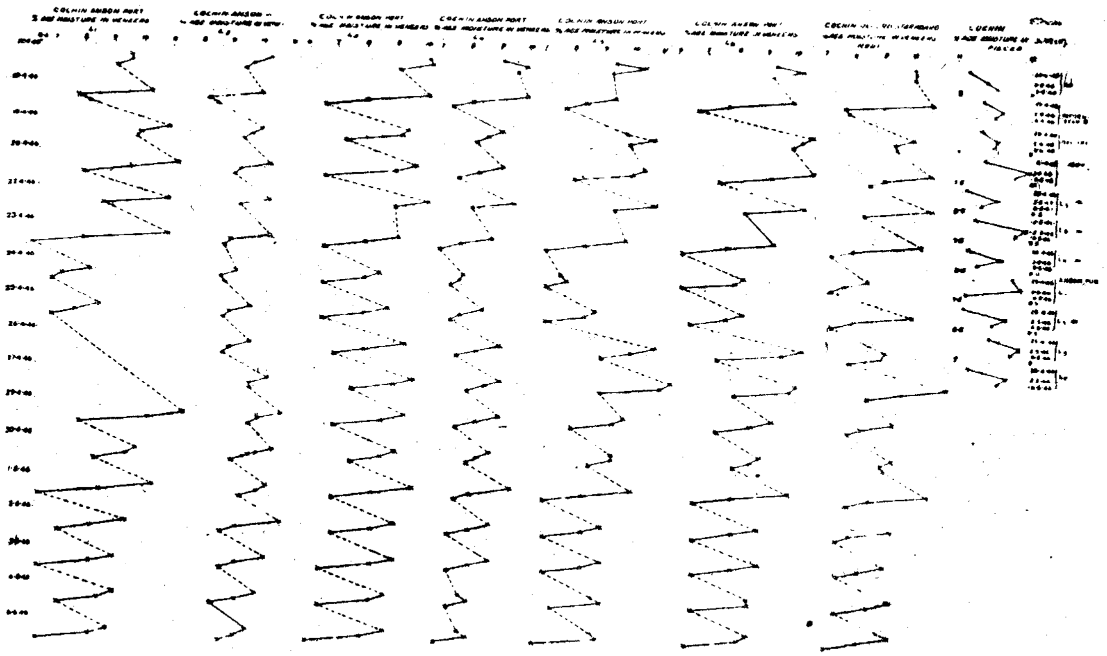

FIG. 65.—Variation of moisture content of veneers, grids and spruce pieces in Anson and Oxford Mainplanes at Cochin.

FIG. 66.—Variation of moisture content of spruce pieces in Anson Mainplane.

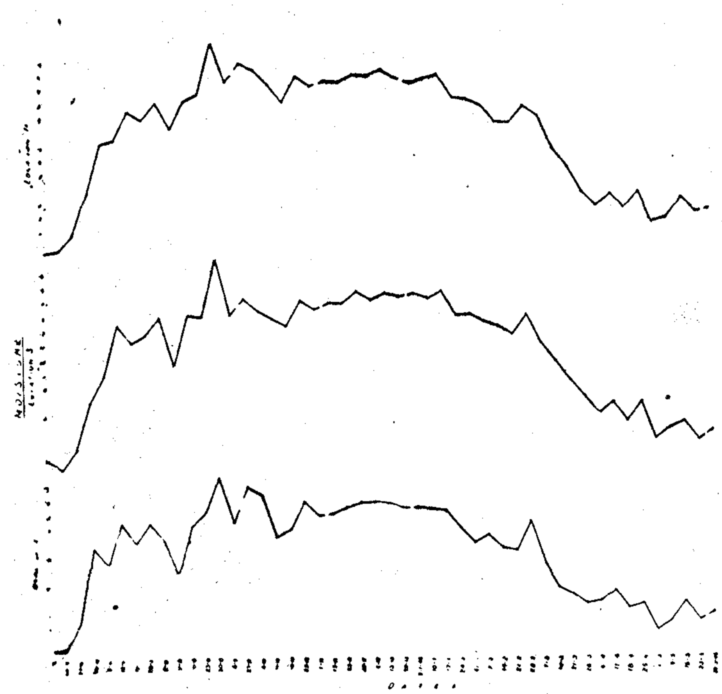

FIG. 67.—Variation of moisture content of grids in Anson Mainplane.

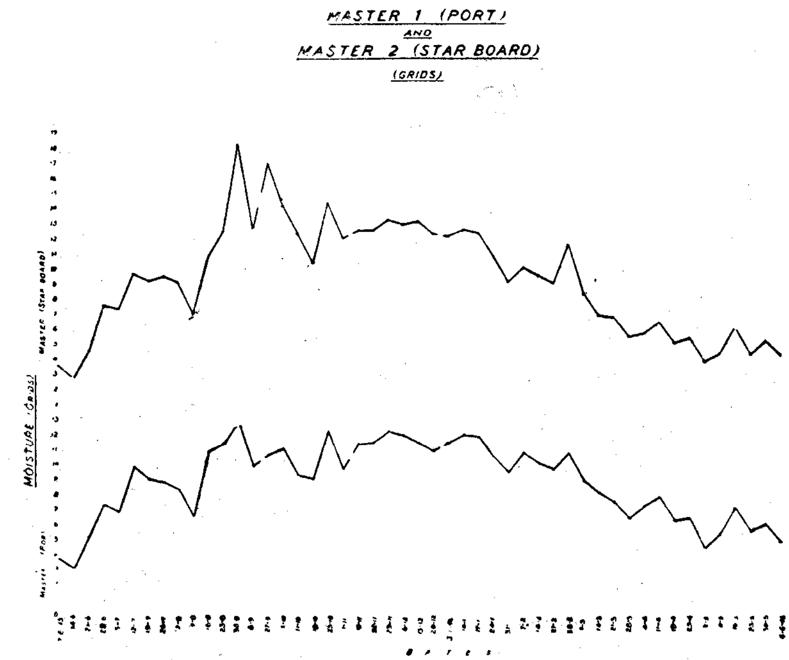

FIG. 68.—Variation of moisture content of grids in Master Mainplane.

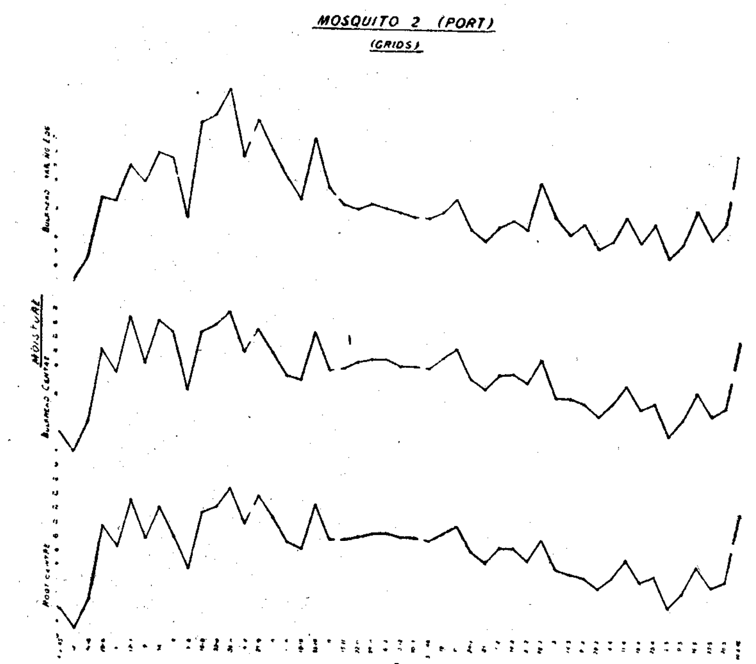

FIG. 69.—Variation of moisture content of grids in Mosquito Port.

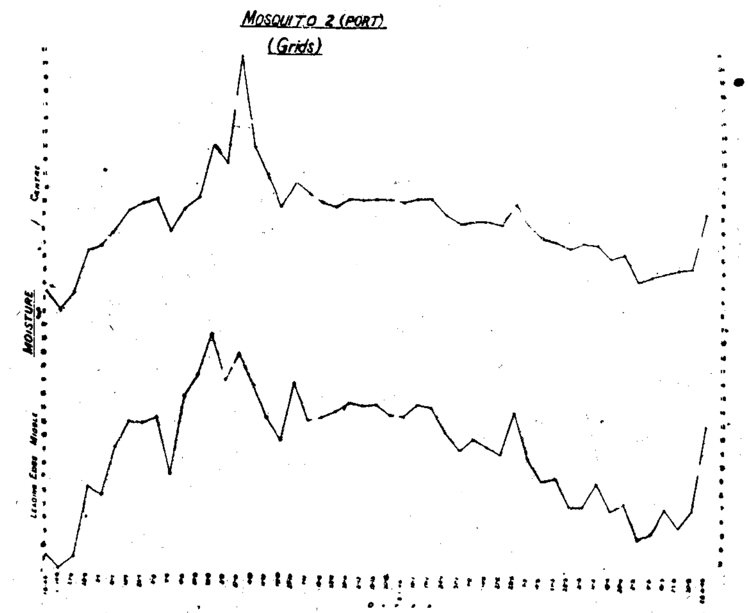

FIG. 70.—Variation of moisture content of grids in Mosquito Port

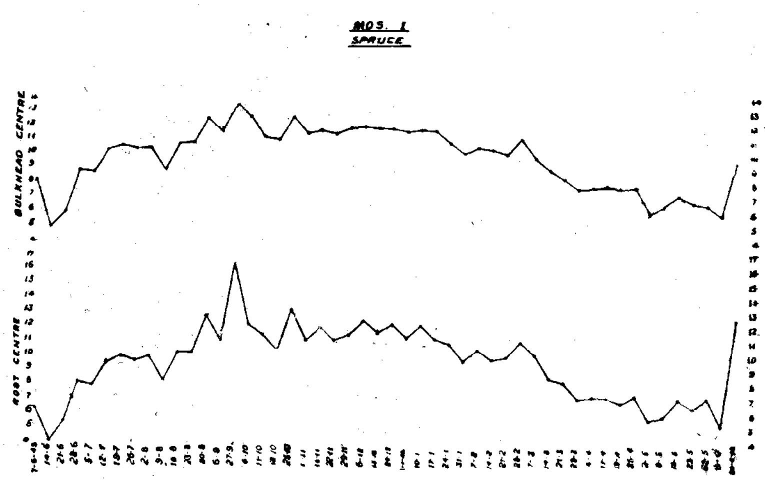

FIG. 71.—Variation of moisture content of spruce pieces in Mosquito Mainplane Starboard.

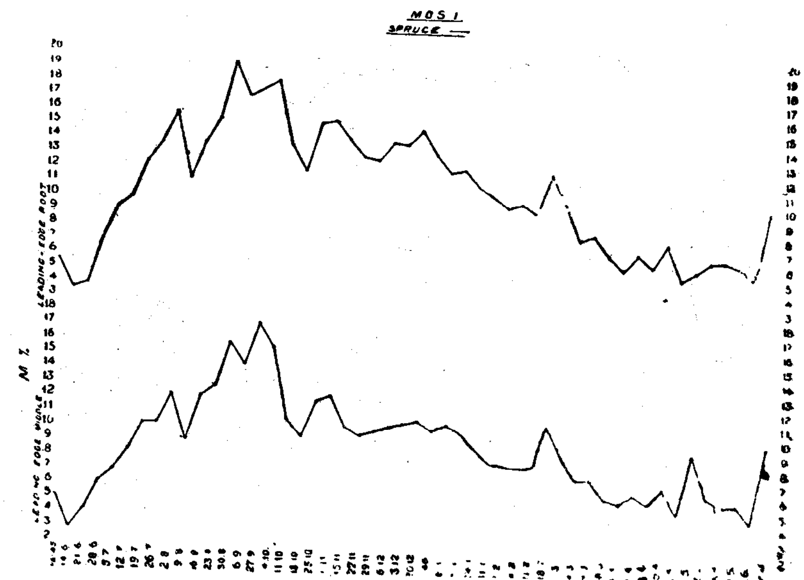

FIG. 72.—Variation of moisture content of spruce pieces in Mosquito Mainplane Starboard.

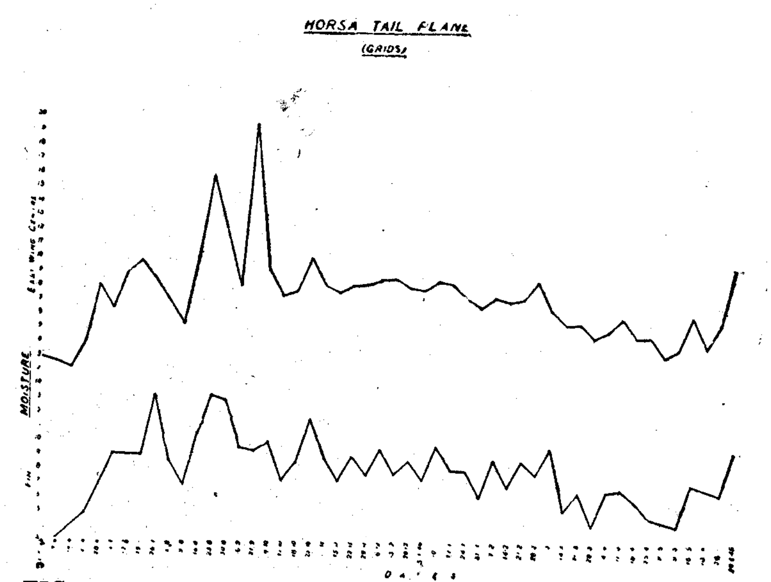

FIG. 73.—Variation of moisture content of grids in Horsa Tail-plane.

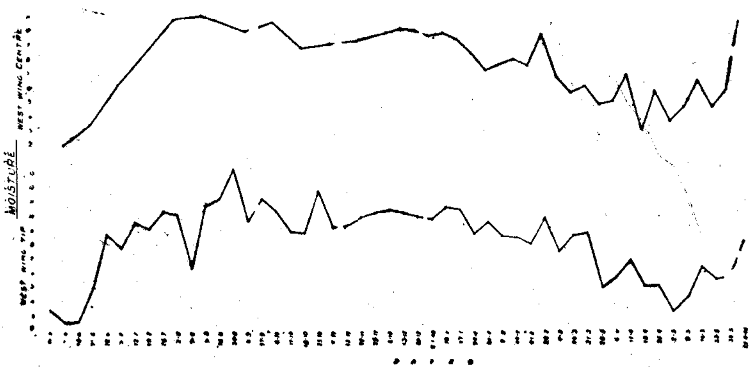

FIG. 74.—Variation of moisture content of grids in Horsa Tailplane.

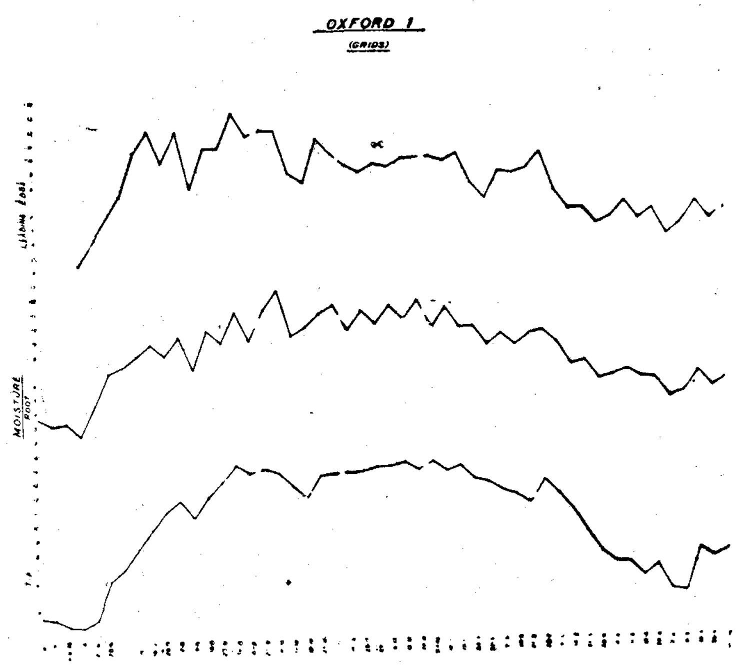

FIG. 75.—Variation of moisture content of grids in Oxford Starboard.

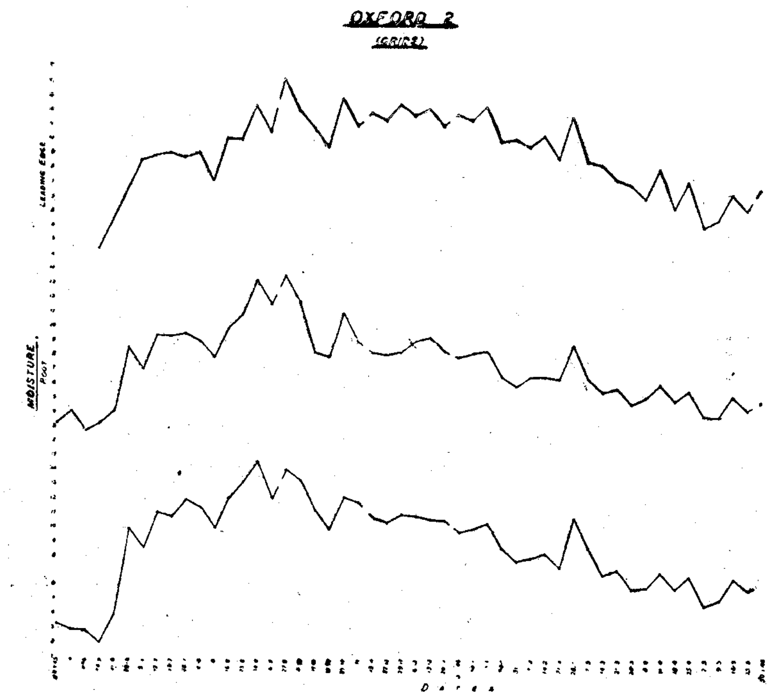

FIG. 76.—Variation of moisture content of grids in Oxford Port.

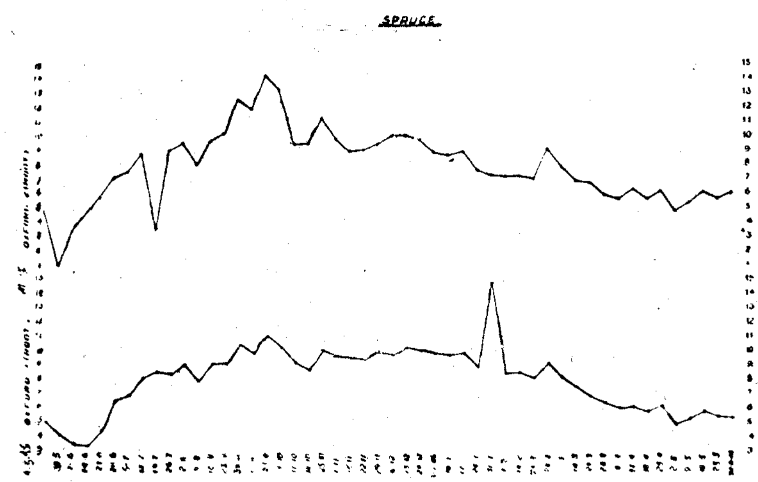

FIG. 77.—Variation of moisture content of spruce pieces in Oxford Mainplane.

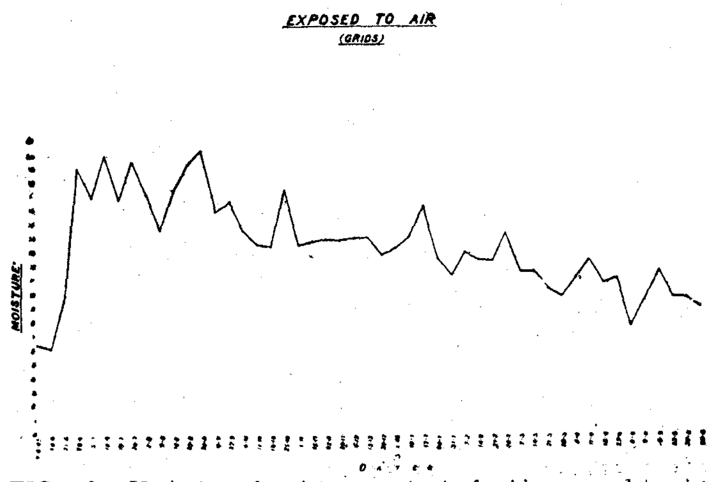

FIG. 78.—Variation of moisture content of grids exposed to air.

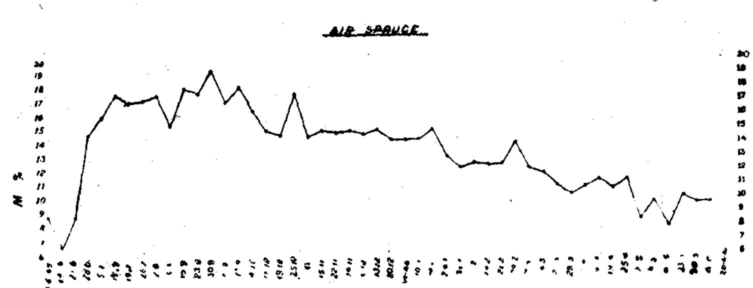

FIG. 79.—Variation of moisture content of spruce pieces exposed to air.

TABLE VI—(*contd.*)

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content %				
			Maximum		Minimum		Difference
			Time	Moisture	Time	Moisture	Moisture
1	2	3	4	5	6	7	8
Mosquito Mainplane Port	Bulkhead	11-6-45	..	..	11·30	0·56	..
		19-9-45	07·30	15·86	..	..	15·30
	Root Centre	11-6-45	..	..	11·30	0·49	..
		4-9-45	07·30	13·98	..	..	13·49
	Centre	13-6-45	..	..	15·30	0·05	..
		11-9-45	11·30	14·02	..	..	13·97
	Leading Edge Middle	12-6-45	..	..	11·30	0·22	..
		27-8-45	11·30	18·47	..	..	18·25
Anson Mainplane Port	1	15-6-45	..	..	15·30	0·11	..
		26-9-45	07·30	18·76	..	..	18·65
	2	11-6-45	..	..	15·30	0·00	..
		3-9-45	07·30	14·89	..	..	14·89
	3	12-6-45	..	..	15·30	0·07	..
		27-8-45	11·30	14·83	..	..	14·76
	4	4-6-45	..	..	15·30	0·00	..
		9-10-45	07·30	17·63	..	..	17·63
Oxford Mainplane Starboard	Root	24-5-45	..	..	15·30	0·01	..
		14-9-45	07·30	9·95	..	..	9·94
	Tip	26-5-45	..	..	15·30	0·00	..
		27-8-45	07·30	13·92	..	..	13·92
Oxford Mainplane Port	Root	26-5-45	..	..	15·30	0·05	..
		26-9-45	07·30	12·28	..	..	12·23
	Tip	28-5-45	..	..	15·30	0·13	..
		25-9-45	11·30	15·41	..	..	15·28

(*contd.*)

TABLE VI—(*contd.*)

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content % — Maximum — Time	Moisture Content % — Maximum — Moisture	Moisture Content % — Minimum — Time	Moisture Content % — Minimum — Moisture	Moisture Content % — Difference — Moisture
1	2	3	4	5	6	7	8
Mango veneers : Oxford Mainplane Port	Root	9–6–45	..	..	11·30	0·00	..
	Top	26–9–45	07·30	14·83	..	..	.. 14·83
	Root	5–6–45	..	..	11·30	0·10	..
	Mid-height	26–9–45	07·30	15·19	..	..	.. 15·09
	Root	9–6–45	..	..	11·30	0·33	..
	Bottom	26–9–45	07·30	13·30	..	..	.. 12·97
	Air	9–6–45	..	..	15·30	1·27	..
		28–6–45	07·30	23·22	..	..	.. 21·95
Zanthoxylum veneers	Air	9–6–45	..	..	15·30	1·04	..
		3–7–45	07·30	27·21	..	..	.. 26·17
Horsa Tailplane	East Wing	25–10–45	12·00	13·00	..	..	..
	Centre	9–6–45	..	..	15·30	0·46	.. 12·54
	West Wing	9–6–45	..	..	15·30	0·13	..
	Centre	25–9–45	15·30	12·03	..	..	.. 11·90
Master Mainplane Port	Root	15–6–45	..	..	15·30	0·64	..
		27–8–45	07·30	14·88	..	..	.. 14·24
..	Tip	14–6–45	..	..	15·30	0·61	..
		26–9–45	07·30	17·48	..	..	.. 16·87
Master Mainplane Starboard	Root	14–6–45	..	..	15·30	0·00	..
		25–9–45	15·30	15·72	..	..	.. 15·72
	Tip	13–6–45	..	..	15·30	0·84	..
		23–10–45	15·30	15·63	..	..	.. 14·79
		VENEERS (COCHIN). 25–5–45 to 16–6–45					
Oxford Mainplane Starboard	1	28–5–45	..	..	13·30	6·3	..
		7–6–45	14·30	16·8	..	..	.. 10·5

(*contd.*)

TABLE VI—(*contd.*)

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content %				
			Maximum		Minimum		Difference
			Time	Moisture	Time	Moisture	Moisture
1	2	3	4	5	6	7	8
Oxford Mainplane Starboard	2	24–5–45	..	..	13·30	5·2	..
		12–6–45	9·00	14·9	..	..	.. 9·7
	3	25–5–45	..	..	14·00	5·7	..
		8–6–45	11·30	18·2	..	..	.. 12·5
Oxford Mainplane Port	1	25–5–45	..	..	14·00	5·3	..
		7–6–45	15·30	17·6	..	..	.. 12·3
	2	24–5–45	..	..	17·30	4·2	..
		7–6–45	14·30	17·6	..	..	.. 13·4
	3	24–5–45	..	..	13·30	5·6	..
		7–6–45	14·30	17·6	..	..	.. 12·0
			13–9–45 to 16–11–45				
Oxford Mainplane Starboard	Root	24–9–45	..	..	10·00	5·02	..
		10–11–45	8·00	10·30	..	..	.. 5·28
	Tip	3–10–45	..	..	15·00	5·05	..
		10–11–45	8·00	9·85	..	..	.. 4·80
Oxford Mainplane Port	Root	3–10–45	..	..	15·00	4·82	..
		10–11–45	8·00	11·91	..	..	.. 7·09
Anson Mainplane Starboard	1	3–10–45	..	..	17·00	6·27	..
		15–11–45	8·00	11·44	..	..	.. 5·17
	2	25–9–45	..	..	17·00	6·19	..
		15–11–45	8·00	13·88	..	..	.. 7·69
	3	26–9–45	..	..	17·00	5·72	..
		4–10–45	21·00	13·77	..	..	.. 8·05
	4	26–9–45	..	..	13·00	7·54	..
		15–11–45	8·00	12·04	..	..	.. 5·50
	5	3–10–45	..	..	17·00	6·84	..
		15–11–45	8·00	13·07	..	..	.. 6·23

(*contd.*)

TABLE VI—(*contd.*)

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content %				
			Maximum		Minimum		Difference
			Time	Moisture	Time	Moisture	Moisture
1	2	3	4	5	6	7	8
Anson Mainplane Starboard	6	13–11–45	..	..	13·00	7·07	..
		13–11–45	8·00	14·23	..	..	..
							7·16
Anson Mainplane Port	1	26–9–45	..	..	13·00	6·21	..
		17–11–45	8·00	15·75	..	..	..
							9·54
	2	4–10–45	..	..	13·00	8·43	..
		10–11–45	9·00	11·77	..	..	..
							3·34
	3	26–9–45	..	..	13·00	6·90	..
		14–11–45	8·00	12·21	..	..	..
							5·31
	4	2–10–45	..	..	17·00	6·56	..
		13–11–45	8·00	11·44	..	..	..
							4·88
	5	4–10–45	..	..	17·00	7·66	..
		13–11–45	8·00	13·74	..	..	..
							6·08
	6	4–10–45	..	..	21·00	6·84	..
		16–11–45	8·00	13·39	..	..	..
							6·55
	Air	3–10–45	..	..	17·00	8·86	..
		10–11–45	8·00	17·40	..	..	..
							8·54
			17–4–46 to 6–5–46				
Oxford Mainplane Starboard	Root	23–4–46	..	..	15·00	7·26	..
		27–4–46	8·00	11·25	..	..	..
							3·99
	Tip	17–4–46	11·30	10·88	..	..	..
		6–5–46	..	..	15·00	6·64	..
							4·24
Oxford Mainplane Port	Root	23–4–46	..	..	15·00	5·99	..
		27–4–46	8·00	11·24	..	..	..
							5·25
	Tip Top	23–4–46	..	..	15·00	5·06	..
		27–4–46	8·00	10·16	..	..	..
							5·10

(*contd.*)

TABLE VI—(*concld.*)

VENEERS (DEHRA DUN)

Plane	Location	Date	Moisture Content %				
			Maximum		Minimum		Difference
			Time	Moisture	Time	Moisture	Moisture
1	2	3	4	5	6	7	8
Oxford Mainplane Port	Tip bottom	23–4–46	..	..	15·00	6·12	..
		27–4–46	8·00	13·22	..	..	..
							7·10
	Air	3–5–46	..	..	15·00	8·15	..
		20–4–46	8·00	14·88	..	..	..
							6·73
Anson Mainplane Starboard	1	17–4–46	11·30	9·80	..	..	..
		24–4–46	..	..	15·00	6·28	..
							3·52
	2	23–4–46	..	..	15·00	6·99	..
		26–4–46	8·00	12·20	..	..	..
							5·21
	3	17–4–46	11·30	10·47	..	..	..
		18–4–46	..	..	15·00	6·23	..
							4·24
	4	17–4–46	11·30	10·47	..	..	..
		6–5–46	..	..	15·00	6·73	..
							3·74
	5	23–4–46	..	..	15·00	6·79	..
		27–4–46	8·00	11·42	..	..	..
							4·63
	6	18–4–46	..	..	15·00	6·36	..
		27–4–46	8·00	12·16	..	..	..
							5·80
Anson Mainplane Port	1	23–4–46	..	..	15·00	6·3	..
		29–4–46	8·00	11·5	..	..	..
							5·2
	2	18–4–46	..	..	11·30	8·2	..
		27–4–46	8·00	10·8	..	..	..
							2·6
	3	17–4–46	11·30	10·2	..	..	..
		6–5–46	..	..	15·00	6·2	..
							4·0
	4	23–4–46	..	..	15·00	7·0	..
		1–5–46	8·00	9·5	..	..	..
							2·5
	5	6–5–46	..	..	15·00	6·8	..
		27–4–46	8·00	11·4	..	..	..
							5·6
	6	23–4–46	..	..	15·00	6·2	..
		19–4–46	8·00	10·6	..	..	..
							4·4

The highest moisture content for veneers in air at Dehra Dun was 27·21% and in the wings it was 19·27% (Mosquito). The lowest figure was 1·04% in air while in the wings it went down to nearly 0%. With the spruce specimens in air they attained 19·37% while the highest recorded in the wings was 19·52% in the Mosquito leading edge. The minimum values were 6·78% in air and 1·04% in the Oxford. The maximum for grids in air was 20·26% and 20·7% in the Mosquito. Corresponding minimum values were 6·06% in air and 1·96% in the Horsa Tail Plane and 2·37% in the Oxford.

(*To be continued*)

A SYSTEMATIC CATALOGUE OF THE MAIN IDENTIFIED ENTOMOLOGICAL COLLECTION AT THE FOREST RESEARCH INSTITUTE, DEHRA DUN

PARTS 4–7*.—ORDERS ORTHOPTERA (*concluded*), DERMAPTERA AND PLECOPTERA

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PART 4.—ORDER ORTHOPTERA (*continued*), FAMILIES MANTIDÆ AND PHASMIDÆ

BY M. L. ROONWAL AND G. D. BHASIN

Family 2. MANTIDÆ
(Praying-insects and mantises)

The family Mantidæ, which contains the praying-insects or mantises, is represented in the collection by 31 genera and 53 species; all are Indian. The modern classification of this family is largely due to the two authorities in the works cited below, viz.,

GIGLIO-TOS, E. 1927. Orthoptera. Mantidæ. *Das Tierreich*, Lief. 50, xl + 707 pp.—Berlin and Leipzig.

BEIER, M. 1934–37. Wytsman's *Genera Insectorum. Mantidæ.* Fascicules 196–203ME and 4 Appendices, 244 + 7 pp., 15 pls.—Brussels.

The 32 subfamilies recognized by Giglio-Tos (1927) are reduced to about one-third that number by Beier (1934–37), and in the present account the later authority is largely followed.

The 31 genera represented in this collection are the following :—

Subfam. 1. Amorphoscelinæ : *Amorphoscelis*.

Subfam. 2. Empusinæ : *Empusa* and *Gongylus*.

Subfam. 3. Hymenopodinæ : *Ambivia*, *Creobroter*, *Ephestiasula*. *Euantissa*, *Hastiasula* and *Odontomantis*.

Subfam. 4. Mantinæ : *Cimantis*, *Deiphobe*, *Didymocorypha*, *Dysaules*, *Gimantis*, *Gonypeta*, *Haldwania*, *Haplopeza*, *Hierodula*, *Humbertiella*, *Leptomantis*, *Mantis*, *Memantis*, *Oxyophthalmus*, *Parahierodula*, *Phyllothelys*, *Rhombodera*, *Schizocephala*, *Statilia*, *Tenodera* and *Tropidomantis* (with subgenus *Eomantis*).

Subfam. 5. Toxoderinæ : *Aethalochroa*.

The type-specimens of 7 species or subspecies, marked in the main list with an asterisk*, are present in the collection, as follows :—

Type-specimens of Mantidæ present in the F.R.I. Coll.

1. *Deiphobe incisa* Werner. (2 paratypes).
2. *Ephestiasula intermedia* Werner. (1 type, 3 paratypes).
3. *Euantissa ornata* Werner. (1 type, 2 paratypes).
4. *Hestiasula nigrofemorata* Werner. (1 type, 1 paratype).
5. *Mantis inornata* Werner. (1 type).

* For a list of the earlier parts, see at the end.

6. *Memantis gardneri* Werner. (1 paratype).
7. *Statilia mauclata continentalis* Werner. (1 type, 1 paratype).

Acknowledgment.—The assistance received by us from Shri G. D. Pant is thankfully acknowledged.

Family MANTIDÆ

Subfamily 1. AMORPHOSCELINÆ

Genus 1. *Amorphoscelis* Stål

14180. *Amorphoscelis indica* Giglio-Tos

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (6), Kalsi (1), Nalapani (1). Unknown locality (2).

16277. *Amorphoscelis* sp.

India.—*Madras* : North Salem, Aiyur (1).

Subfamily 2. EMPUSINAE

Genus 1. *Empusa* Illiger

2517. *Empusa fasciata* Brulle

India—*Bihar* : Pusa (1).

Genus 2. *Gongylus* Thunberg

16280. *Gongylus gongylodes* Linnæus

India.—*Madras* : North Salem, Aiyur (1).

Subfamily 3. HYMENOPODINAE

Genus 1. *Ambivia* Stål

14553. *Ambivia popa* Stål

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (3), Kalsi (1).

Genus 2. *Creobroter* Serville

14174. *Creobroter apicalis* Saussure

India.—*Bengal* : Chittagong, Kaptai (1). *Madras* : South Mangalore, 400 ft. (1). *Uttar Pradesh* : Dehra Dun, Malhan (1) ; Haldwani, Chakata range (3).

16278. *Creobroter gemmatus* Stoll

India.—*Madras* : North Arcot, Kottur (Vellore) 3700 ft. (2) ; North Salem, Aiyur (1).

1093. *Creobroter urbana* Fabricius

India.—*Bihar* : Pusa (1). *Burma* : Katha, Mohnyin reserve (1). *Punjab* : Chichawatni (1). *Uttar Pradesh* : Dehra Dun, Dehra Dun (9 adults +6 nymphs +3 oothecæ), Malhan (1). Unknown locality (1).

Genus 3. *Ephestiasula* Giglio-Tos

13540. **Ephestiasula intermedia* Werner

India.—*Madhya Pradesh* : Buldana, Sagoda, Purna (1). *Uttar Pradesh* : Dehra Dun, Dehra Dun (1 *type* +3 *paratypes* +4), Thano (1) ; Haldwani, Chakhata (1).

15445. *Ephestiasula pictipes* Wood-Mason

India.—*Uttar Pradesh* : Dehra Dun (5). Unknown locality (1).

Genus 4. *Euantissa* Giglio-Tos

15446. **Euantissa ornata* Werner

India.—*Bengal* : Dacca (1 ♀ *type* + 1 ♂ *paratype*). *Uttar Pradesh* : Dehra Dun (1 ♀ *paratype* +4).

16279. *Euantissa pulchra* Fabricius

India.—*Madras* : North Arcot, Kottur (Vellore) 3,700 ft. (1) ; North Salem, Aiyur (4), Jawalagiri (9).

Genus 5. *Hestiasula* Saussure

13541. *Hestiasula brunneriana* Saussure

India.—*Madras* : Nilambur (1). *Uttar Pradesh* : Dehra Dun, Dehra Dun (7), Kalsi (1).

13542. **Hestiasula nigrofemorata* Werner

India.—*Uttar Pradesh* : Dehra Dun (1 ♂ *type* +1 ♀ *paratype*).

Genus 6. *Odontomantis* Saussure

16281. *Odontomantis micans* Stål

India.—*Madras* : North Arcot, Kottur (Vellore) 3,700 ft. (1) ; North Salem, Aiyur (1). *Mysore & Coorg* : South Coorg : Tithimatti (2).

Subfamily 4. MANTINAE

Genus 1. *Cimantis* Giglio-Tos

14178. *Cimantis fuliginosa* Werner

India.—*Madras* : Annamalai Hills, 2,400 ft. (3). *Mysore & Coorg* : South Coorg : Nagerhole (2), Tithimatti (1). *Orissa* : Angul : Tarva (1).

Genus 2. *Deiphobe* Stål

14555. **Deiphobe incisa* Werner

India.—*Punjab* : Chichawatni (2). *Uttar Pradesh* : Etawah (1 ♀ *paratype*) ; Haldwani : Chakhata range (1 ♂ *paratype*).

14557. *Deiphobe incisa* Werner (subsp. nov. ?)

India.—*Madhya Pradesh* : Buldana, Sagoda, Purna range (1).

14558. ***Deiphobe infuscata*** Saussure

India.—*Madhya Pradesh*: Balaghat, Supkhar (1). *Uttar Pradesh*: Dehra Dun, Dehra Dun (5 adults +6 nymphs), Lachiwala (1); Mussoorie (1).

Genus 3. ***Didymocorypha*** Wood-Mason

14554. ***Didymocorypha lanceolata*** Fabricius

India.—*Madhya Pradesh*: Raipur: Birguri (1). *Uttar Pradesh*: Dehra Dun (2).

Genus 4. ***Dysaules*** Stål

14176. ***Dysaules himalayanus*** Wood-Mason

India.—*Madhya Pradesh*: Hoshangabad, Rahatgaon (1). *Uttar Pradesh*: Dehra Dun (2); Haldwani, Chakhata range (1).

Genus 5. ***Gimantis*** Giglio-Tos

14173. *Gimantis authœmon* Wood-Mason

India.—*Burma*: North Toungoo, Pyonchaung (2).

Genus 6. ***Gonypeta*** Saussure

14559. ***Gonypeta puctata*** Haan

India.—*Madras*: Nilambur (2). *Mysore & Coorg*: South Coorg, Nagerhole (2).

Genus 7. ***Haldwania*** Beier

14182. ***Haldwania liliputana*** Beier

India.—*Uttar Pradesh*: Dehra Dun (3).

Genus 8. ***Haplopeza*** Stål

14560. ***Haplopeza nilgirica*** Wood-Mason

India.—*Madras*: Anamalai Hills, 2,400 ft. (2).

Genus 9. ***Hierodula*** Burmeister

14556. ***Hierodula bipapilla*** Serville

India.—*Uttar Pradesh*: Dehra Dun (1).

15447. ***Hierodula ventralis*** Giglio-Tos

India.—*Madhya Pradesh*: Hoshangabad, Rahatgaon (1). *Madras*: North Salem, Aiyur (1), Jawalagiri (1).

1104. ***Hierodula tenuidentata*** Saussure

(Syn. *H. westwoodi* Kirby)

India.—*Bihar*: Pusa (1). *Uttar Pradesh*: Dehra Dun, Dehra Dun (3 adults +6 nymphs +3 oothecæ), Lachiwala (1). Unknown locality (1).

Genus 10. ***Humbertiella*** Saussure

14181. ***Humbertiella ceylonica*** Saussure

India.—*Madhya Pradesh*: South Mandla, Motinala range (1). *Punjab*: Chichawatni plantations (1), Miranpur plantations (1). *Uttar Pradesh*: Dehra Dun, Golatapper (2), Kalsi (1), New Forest (1), Thano (2); Haldwani, Chakhata range (1).

2519. *Humbertiella indica* Saussure

India.—*Bombay* : Bassein fort (1). *Madras* : North Salem, Aiyur (2 adults +1 nymph). *Mysore & Coorg* : South Coorg : Nagerhole (1). *Uttar Pradesh* : Dehra Dun, New Forest (1).

Genus 11. *Leptomantis* Giglio-Tos

13546. *Leptomantis indica* Giglio-Tos

India.—*Assam* : Gauhati (1). *Mysore & Coorg* : South Coorg : Tithimatti (2).

14561. *Leptomantis parva* Werner

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (4), Lachiwala (1).

Genus 12. *Mantis* Linnæus

13544. **Mantis inornata* Werner

India.—*Uttar Pradesh* : Dehra Dun, Golatapper (1 ♀ *type*). Unknown locality (1).

13543. *Mantis nobilis* Brunner

India.—*Mysore & Coorg* : North Coorg, Fraserpet (1). *Uttar Pradesh* : Dehra Dun (5).

15449. *Mantis religiosa* Linnæus

India.—*Uttar Pradesh* : Dehra Dun (3).

Genus 13. *Memantis* Giglio-Tos

14179. **Memantis gardneri* Werner

India.—*Uttar Pradesh* : Kumaon, Taraket (1 ♂ *paratype*).

Genus 14. *Oxyophthalmus* Saussure

16282. *Oxyophthalmus gracilis* Saussure

India.—*Madras* : North Arcot, Kottur (Vellore) 3,700 ft. (2) ; North Salem, Aiyur (2), Jawalagiri (4). *Mysore & Coorg* : North Coorg, Fraserpet (4).

Genus 15. *Parhierodula* Giglio-Tos

16283. *Parhierodula coarctata* Saussure

India.—*Madras* : North Salem, Denkanikota (1). *Punjab* : Chichawatni (2).

16284. *Parhierodula venosa* Olivier

India.—*Madras* : North Salem, Jawalagiri (1). *Mysore & Coorg* : S. Coorg : Tithimatti (1).

16285. *Parhierodula* sp.

India.—*Madras* : North Salem, Denkanikota (1), Uduparani (1).

Genus 16. *Phyllothelys* Wood-Mason

14175. *Phyllothelys westwoodi* Wood-Mason

India.—*Uttar Pradesh* : Dehra Dun (1).

Genus 17. *Rhombodera* Burmeister

4476. *Rhombodera tectiformis* Saussure

India.—*Uttar Pradesh* : Dehra Dun (6).

Genus 18. *Schizocephala* Serville

2516. *Schizocephala bicornis* Linnæus

India.—*Bombay* : Surat (1).

18343. *Schizocephala* sp.

India.—*Punjab* : Chichawatni plantations (1).

Genus 19. *Statilia* Stål

14177. *Statilia maculata* Thunberg

India.—*Assam* : Shillong (1). *Mysore & Coorg* : S. Coorg, Nagerhole (3). *Uttar Pradesh* : Dehra Dun, Dehra Dun (1), Golatapper (1), Kalsi (1), Lachiwala (1). Unknown locality (1).

15448. **Statilia maculata continentalis* Werner

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (1 ♀ *type*), Thano (♂ *paratype*).

Genus 20. *Tenodera* Burmeister

15450. *Tenodera angustipennis* Saussure

India.—*Uttar Pradesh* : Dehra Dun (1).

14562. *Tenodera aridifolia* Stoll

India.—*Assam* : Sylhet (1).

15451. *Tenodera fasciata* Olivier

India.—*Bengal* : Buxa, Rajabhatkhawa (1).

2518. *Tenodera superstitiosa* Fabricius

India.—*Bihar* : Pusa (1). *Punjab* : Chichawatni plantations (1).

Genus 21. *Tropidomantis* Stål

(SYN. : Subgenus *Eomantis* Giglio-Tos, in part).

13545 & 16286. *Tropidomantis guttatipennis* Stål

India.—*Assam* : Gauhati (1). *Madras* : North Salem, Aiyur (2), Jawalagiri (2). *Mysore & Coorg* : South Coorg : Nagerhole (1). *Uttar Pradesh* : Dehra Dun, Kalsi (1).

Subfamily 5. TOXODERINAE

Genus 1. *Aethalochroa* Wood-Mason

13539. *Aethalochroa ashmoliana* Westwood

India.—*Uttar Pradesh* : Dehra Dun (3) ; Etawah (1).

Family 3.—PHASMIDÆ

(Stick-insects, leaf-insects)

This large family of leaf-insects and stick-insects is practically unrepresented in the collection, there being but 3 species present. It is hardly necessary to say that additions to the collection would be most welcome. No type-specimens are present.

Genus 1. *Rhamphophasma* Brunner

16287. *Rhamphophasma mallati* Brunner

India.—*Madras* : North Salem, Jawalagiri (1).

Genus 2. *Trachythorax* Redtenbacher

16288. *Trachythorax maculicollis* Westwood

India.—*Mysore & Coorg* : North Coorg, Fraserpet (2).

16289. *Trachythorax planiceps* Redtenbacher

India.—*Madras* : North Salem, Aiyur (2), Jawalagiri (2).

PART 5.—ORDER ORTHOPTERA (*continued*), FAMILY ACRIDIDÆ

BY M. L. ROONWAL, G. D. BHASIN and S. D. MISRA

Family 4.—ACRIDIDÆ (including Acrydiidæ or Tetrigidæ)

(Short-horned grasshoppers and locusts)

The family Acrididæ, which includes the short-horned grasshoppers and locusts, is represented in the collection by 64 genera and about 108 species and subspecies, mainly Indian. There are a few foreign specimens, mainly from Iraq ; *Melanoplus femur-rubrum* is from North America. No type-specimens are present.

The total of 64 genera are distributed in 5 subfamilies as follows ; the subfamily Acrydiinæ or Tetriginæ is considered by some authorities a separate family, viz., Acrydiidæ or Tetrigidæ.

List of genera of Acrididæ present in the Forest Research Institute Collection.

Subfam. 1. Acridinæ (or Truxalinæ) : *Acrida, Acridella, Aeolopus* (Syn. *Epacromia*), *Aulacobothrus, Ceracris, Duroniella, Phlœoba* and *Stauroderus.*

Subfam. 2. Acrydiinæ (or Tetriginæ): *Criotettix, Eugavialidium, Euparatettix, Gavialidium, Hedotettix, Scelimena, Sjœstedtia, Systolederus, Thorodonta.*

Subfam. 3. Catantopinæ : *Acœropa, Anacridium, Caloptenopsis, Catantops, Chondracris, Chorœdocus, Coptacra, Cyrtacanthacris, Epistaurus, Eucoptacra, Euprepocnemis, Euthymia, Gesonia, Hieroglyphus, Melanoplus, Oxya, Oxyrrhepes, Pachyacris, Patanga, Pirithous, Schistocerca, Spathosternum, Teratodes, Thisoicetrinus, Thisoicetrus, Tristria, Tropidopola* and *Tylotropidius.*

Subfam. 4. Oedipodinæ : *Acrotylus, Bababuddinia, Dittopternis, Gastrimargus, Heteropternis, Locusta, Oedaleus, Pteroscirta, Pusa, Quiroguesia, Sphingonotus* and *Trilophidia.*

Subfam. 5. Pyrgomorphinæ : *Atractomorpha, Aularches, Chlorizeina, Chrotogonus, Orthacris, Pœcilocerus* and *Pyrgomorpha.*

Acknowledgments.—We are thankful for the assistance received from Dr. B. P. Uvarov (London) and Mr. G. D. Pant (Dehra Dun) regarding information on the position of certain genera and subfamilies.

Family 4.—ACRIDIDÆ

Subfamily 1. ACRIDINÆ (or Truxalinæ)

Genus 1. *Acrida* Linnæus

2522. *Acrida exaltata* Walker

India.—*Madras* : Nilambur (3). *Uttar Pradesh* : Allahabad (1) ; Almora : Kali Valley 3,000 ft. (1) ; Dehra Dun, Dehra Dun (2), Thano (2).

6203. *Acrida gigantea* Herbst

India.—*Bihar* : Pusa (1). *Uttar Pradesh* : Dehra Dun, Dehra Dun (6), Kansrao (1) ; Gonda (1 adult, 2 hoppers). Unknown locality (1).

7390. *Acrida turrita* Linnæus

India.—*Bihar* : Pusa (1). *Burma* : Pyinmana, Yanaungmyin reserve (1). *Uttar Pradesh* : Dehra Dun (5). Unknown locality (3).

Genus 2. *Acridella* Boliver

6204. *Acridella nasuta* Linnæus

India.—*Madras* : N. Salem, Jawalagiri (2). *Uttar Pradesh* : Gonda (1).

7391. *Acridella robusta* Uvarov

Extra-Indian.—ASIA : *Iraq* : Amara (3).

Genus 3. *Aeolopus* Fieber

(SYN. *Epacromia* Fischer)

10587. *Aeolopus affinis* Bolivar

India.—*Uttar Pradesh* : Dehra Dun (1).

2525. *Aeolopus dorsalis* Thunberg

India.—*Madhya Pradesh* : Bhilsa (1).

9314. *Aeolopus tamulus* Fabricius

India.—*Bengal* : Dacca (1). *Madras* : Nilambur (2).

7397. *Aeolopus thalassinus* Fabricius

Extra-Indian.—ASIA : *Iraq* : Amara (8).

Genus 4. *Aulacobothrus* Bolivar

16291. *Aulacobothrus decisus* Walker

India.—*Madras* : N. Salem, Jawalagiri (1).

9859. *Aulacobothrus luteipes* Walker

India.—*Madhya Bharat* : Rewa State, Amarkantak 3,500 ft. (8). *Madras* : Nilambur (3). *Uttar Pradesh* : Dehra Dun (1).

9308. *Aulacobothrus* sp.

India.—*Assam* : Naga Hills 4,000 ft. (2).

16292. *Aulacobothrus* sp.

India.—*Madras* : N. Salem, Jawalagiri (1).

Genus 5. *Ceracris* Walker

7407. *Ceracris deflorata* Brunner

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (8), Thano (1). Unknown locality (2).

9723. *Ceracris fasciata* Brunner

India.—*Uttar Pradesh* : Dehra Dun (1).

Genus 6. *Duroniella* Bolivar

7395. *Duroniella lucasi* Krauss

Extra-Indian.—ASIA : *Iraq* : Amara (3).

Genus 7. *Phlæoba* Stål

7392. *Phlæoba panteli* Bolivar

India.—*Uttar Pradesh* : Dehra Dun (1).

9766. *Phlæoba ramkrishnai* Bolivar

India.—*Madras* : Nilambur, Nedugayam (6).

Genus 8. *Stauroderus* Bolivar

8633. *Stauroderus bicolor* Charpentier

India.—Unknown locality (1).

8635. *Stauroderus bonneti* Bolivar

India.—*Uttar Pradesh* : Dehra Dun (1). Unknown locality (1).

8634. *Stauroderus exemplaris* Bolivar

India.—*Uttar Pradesh* : Dehra Dun (6). Unknown locality (3).

Subfamily 2. ACRYDIINAE (or Tetriginæ)

Genus 1. *Criotettix* Bolivar

9722. *Criotettix grandis* Hancock

India.—*Assam* : Cachar, Haflong (1) ; Shillong (1). *Uttar Pradesh* : Kalagarh (1).

Genus 2. *Eugavialidium* Hancock

9306. *Eugavialidium india* Hancock

India.—*Assam* : Naga Hills, 4,000 ft. (19).

Genus 3. *Euparatettix* Hancock

9764. *Euparatettix parvus* Hancock

India.—*Madras* : Nilambur, Nedungayam (1).

7478. *Euparatettix personatus* Bolivar

India.—*Bengal* : Tipperah (3). *Madras* : Nilambur (2). *Uttar Pradesh* : Dehra Dun (1).

9762. *Euparatettix variabilis* Bolivar

India.—*Madras* : Nilambur (5).

Genus 4. *Gavialidium* Saussure

9310. *Gavialiduim* sp.

India.—*Assam* : Manipur, Shugnu (1).

Genus 5. *Hedotettix* Bolivar

12587. *Hedotettix gracilis* De Haan

India.—*Madras* : Nilambur, Nedungayam (1). *Mysore & Coorg* : North Coorg, Fraserpet (1). *Uttar Pradesh* : Dehra Dun (2).

Genus 6. *Scelimena* Serville

12589. *Scelimena harpago* Serville

India.—*Madhya Bharat* : Rewah : Umaria, Jaithari Range (8), Lalpur (3).

Genus 7. *Sjœstedtia* Bolivar

12586. *Sjœstedtia darjeelingensis* Bolivar

India.—*Uttar Bharat* : Dehra Dun (3).

Genus 8. *Systolederus* Bolivar

9307. *Systolederus cinereus* Brunner

India.—*Assam* : Naga Hills 4,000 ft. (1).

Genus 9. *Thorodonta* Jos.

9315. *Thorodonta sinuata* Hancock

India.—*Madras* : Nilambur (1).

9311. *Thorodonta* sp.

India.—*Assam* : Manipur, Shugnu (1).

Subfamily 3. CATANTOPINAE

Genus 1. *Acaeropa* Uvarov

16290. *Acaeropa indica* Bolivar

India.—*Madras* : N. Salem, Aiyur (1).

Genus 2. *Anacridium* Uvarov

7411. *Anacridium aegyptium* Linnæus

(SYN. *Orthacanthacris ægyptia L*)

Extra-Indian.—ASIA : *Iraq* : Amara (2 ♂ ♂, 6 ♀ ♀).

Genus 3. *Caloptenopsis* Bolivar

2534. *Caloptenopsis glaucopis* Walker

India.—*Madhya Pradesh* : Katni (1).

Genus 4. *Catantops* Schaum

7474. *Catantops acuticercus* Bolivar

India.—*Uttar Pradesh* : Haldwani (1).

7409. *Catantops humilis* Serville

India.—*Madras* : Nilambur (1) ; Nilambur, Nedungyam Reserve (1). *Uttar Pradesh* : Dehra Dun (5) ; Kheri (1). Unknown locality (1).

7410. *Catantops innotabile* Walker

India.—*Madras* : Nilambur (9). *Uttar Pradesh* : Dehra Dun (5) ; Etawah (2).

10590. *Catantops karnyi* Kirby

India.—*Mysore & Coorg* : North Coorg, Fraserpet (1).

8715. *Catantops pinguis* Stål

India.—*Madras* : Nilambur (6). *Uttar Pradesh* : Almora, Kali Valley 3,000 ft. (1).

10589. *Catantops pulchellus* Walker

India.—*Madras* : Madura (1).

8716. *Catantops splendens* Thunberg

India.—*Uttar Pradesh* : Dehra Dun (3).

Genus 5. *Chondacris* Uvarov

7414. *Chondracris rosea* De Geer

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (2), Thano (1). Unknown locality (1).

Genus 6. *Chorœdocus* Bolivar

2533. *Chorœdocus illustris* Walker

India.—*Bihar* : Pusa (1). *Punjab* : Montgomery (1), Multan (1). *Uttar Pradesh* : Dehra Dun (1).

10742. *Chorœdocus capensis* Thunberg

(SYN.—*Heteracris insignis* Walker)

India.—*Uttar Pradesh* : Dehra Dun (1).

17433. *Chorœdocus robusta* Serville

India.—*Bengal* : Kalimpong, Samsing 1,800 ft. (4).

Genus 7. *Coptacra* Stål

2531. *Coptacra fædata* Serville

India.—*Bihar :* Pusa (1).

1857. *Coptacra punctaria* Walker

India.—*Madras :* Nilambur (1).

Genus 8. *Cyrtacanthacris* Walker

7415. *Cyrtacanthacris tatarica* Linnæus

India.—*Bihar* : Pusa (1). *Kashmir* : Jammu (1). *Madras* : Nilambur (1) ; Nilambur, Chatambarai (2). *Uttar Pradesh* : Dehra Dun (1) ; Etawah (Afforestation Division) (1).

Genus 9. *Epistaurus* Bolivar

9312. *Epistaurus sinetyi* Bolivar

India.—*Madras* : Nilambur (1).

Genus 10. *Eucoptacra* Bolivar

9309. *Eucoptacra* sp.

India.—*Assam* : Naga Hills (1).

8636. *Eucoptacra incompleta* Walker

India.—*Uttar Pradesh* : Dehra Dun (1).

9856. *Eucoptacra saturata* Walker

India.—*Madras* : Nilambur (2).

Genus 11. *Euprepocnemis* Fieber

9863. *Euprepocnemis alacris* Serville

India.—*Madras* : Nilambur (6) ; Shevroy Hills 4,000 ft. (1).

9765. *Euprepocnemis shirakii* Bolivar

India.—*Madras* : Nilambur (4).

Genus 12. *Euthymia* Stål

16294. *Euthymia kirbyi* Finot

India.—*Madras* : N. Salem, Jawalagiri (2).

12588. *Euthymia* sp.

India.—*Madhya Pradesh* : Balaghat, Baihar (1).

Genus 13. *Gesonia* Stål

18796. *Gesonia punctifrons* Stål

India.—*Bengal* : Calcutta (2 ♂ ♂ , 2 ♀ ♀ , 4 nymhs).

Genus 14. *Hieroglyphus* Krauss

2529. *Hieroglyphus banian* Fabricius

(SYN. *Hieroglyphus furcifer* Serville)

India.—*Bihar* : Pusa (1). *Madras* : Coimbatore (1 damaged macropterous form). *Punjab* : Hoshiarpur (14). *Uttar Pradesh* : Dehra Dun (3). Unknown locality (3).

18787. *Hieroglyphus nigrorepletus* Bolivar

India.—*Madras* : Bellary District (1 damaged), Siruguppa (1 macropterous form). *Rajasthan* : Ajmer (1 macropterous, 3 micropterous forms). *Uttar Pradesh* : Banaras (3 micropterous, 2 macropterous forms). Unknown locality (1).

Genus 15. *Melanoplus* Stål

9289. *Melanoplus femur-rubrum* De Geer

Extra-Indian.—N. AMERICA : *U.S.A.* : La Fayette (Indiana) (2). (1 tube of hoppers in spirit, locality unknown, but probably U.S.A.).

Genus 16. *Oxya* Serville

10588. *Oxya apta* Walker

India.—*Uttar Pradesh* : Dehra Dun (1 ♂ , 1 ♀).

2528. *Oxya velox* Fabricius

India.—*Bihar* : Pusa (2). *Madras* : Nilambur, Nedungayam (2).

Genus 17. *Oxyrrhepes* Stål

9466. *Oxyrrhepes extensa* Walker

India.—*Assam* : Manipur 2,578 ft. (1).

Genus 18. *Pachyacris* Uvarov

8719 & 7412. *Pachyacris vinosa* Walker

India.—*Assam* : Manipur 2,678 ft. (1) ; Naga Hills (1). *Madhya Pradesh* : Balaghat, Supkar (Raigarh Reserve) (1). *Madras* : Nilambur, Nedungayam (2), tube No. 71 (1). *Uttar Pradesh* : Almora (1) ; Dehra Dun (8), Kalsi (1).

Genus 19. *Patanga* Uvarov

8720. *Patanga succincta* (?subsp.) Linnæus

(Bombay Locust)

India.—*Madhya Pradesh* : Bilaspur (1). *Uttar Pradesh* : Dehra Dun (2) ; Chakrata, Mundali (1).

10586. *Patanga succincta japonica* Bolivar

India.—*Uttar Pradesh* : Naini Tal (1 ♀) ; Almora, Siuni (1 ♂).

Genus 20. ***Pirithous*** Bolivar

9858. ***Pirithous ramachandrai*** Bolivar

India.—*Madras* : Nilambur (2).

Genus 21. *Schistocerca* Stål

8717. *Schistocerca gregaria* Forskål

(Desert Locust)

(*a*) Phase *solitaria*

India.—*Rajasthan* : Bikaner District, Kakko (1 ♂ 5-eye-striped* from an incipient swarm in first year of a new locust cycle commenced 1949).

(*b*) Phase *gregaria*

India.—*Bihar* : Pusa (1). *Bombay* : W. Khandesh Dhulia (4). *Rajasthan* : Ajmer (15, from a small swarm, June 1950). *Uttar Pradesh* : Dehra Dun (6).

Extra-Indian.—ASIA : *Iraq* : Amara (1 ♂).

Genus 22. *Spathosternum* Karsch

2530. *Spathosternum prasiniferum* Walker

India.—*Bihar* : Pusa (2). *Madras* : N. Salem, Aiyur (1) ; Nilambur (6). *Madhya Bharat* : Rewah, Amarkantak 3,500 ft. (3). *Mysore & Coorg* : North Coorg, Fraserpet (1 damaged + 1). *Punjab* : Rawalpindi (West) 4,000 ft. (1). *Uttar Pradesh* : Dehra Dun (15), Kalsi (1), Thano (1).

Genus 23. *Teratodes* Brullé

2527. *Teratodes monticollis* Gray

India.—*Bombay* : Poona (1). *Madhya Pradesh* : Balaghat (1) ; Hoshangabad, Rahatgaon (1). *Madras* : N. Salem, Aiyur (1 damaged), Jawalagiri (1). *Punjab* : Rawalpindi (1 hopper). *Uttar Pradesh* : Dehra Dun (1) ; Gonda (1 hopper).

Genus 24. *Thisoicetrinus* Uvarov

7402. *Thisoicetrinus dorsatus* Fischer de Waldheim

Extra-Indian.—ASIA : *Iraq* : Amara (1 ♂ , 1 ♀).

Genus 25. *Thisoicetrus* Brunner

(SYN. *Thisœcetrus* Jacobson & Bianchi)

7400. *Thisoicetrus adspersus* Redtenbacher

Extra-Indian.—ASIA : *Iraq* : Amara (1).

7401. *Thisoicetrus littoralis* Ramb. (*var. minuta* nov.)

Extra-Indian.—ASIA : *Iraq* : Amara (1 ♂ , 1 ♀).

* This is the first record of a 5-eye-striped individual obtained *in nature*. The usual number of eye-stripes in the *solitaria* phase of the Desert Locust is either 6 or 7 (*vide* Roonwal *Current Sci.*, Bangalore, 5 (1936), p. 24; and *Proc. R. Soc. London* (*B*), 134 (1947), pp. 245–272).

10585. *Thisoicetrus pulcher* Bolivar

India.—*Punjab* : Montgomery (2). *Uttar Pradesh* : Dehra Dun, Kalsi (2).

Genus 26. *Tristria* Stål

12585. *Tristria pulvinata* Uvarov

India.—*Madras* : Nilambur, Nedungayam (2).

Genus 27. *Tropidopola* Stål

7396. *Tropidopola cylindrica obtusa* Uvarov

Extra-Indian.—ASIA : *Iraq* : Amara (3).

Genus 28. *Tylotropidius* Stål

8718. *Tylotropidius varicornis* Walker

India.—*Madhya Pradesh* : Raipur, Birguri (1) ; Hoshangabad, Panchmarhi 3,500 ft. (4).

Subfamily 4. OEDIPODINAE

Genus 1. *Acrotylus* Fieber

7405. *Acrotylus humbertianus* Saussure

India.—*Uttar Pradesh* : Allahabad (2) ; Dehra Dun (18). Unknown locality (2).

Genus 2. *Bababuddinia* Bolivar

9763. *Bababuddinia bizonata* Bolivar

India.—*Madras* : Nilambur (1).

Genus 3. *Dittopternis* Saussure

9313. *Dittopternis venusta* Walker

India.—*Madras* : Nilambur (4). *Mysore & Coorg* : North Coorg, Fraserpet (1).

Genus 4. *Gastrimargus* Saussure

2524. *Gastrimargus transversus* Thunberg

India.—*Bihar* : Pusa (1). *Madhya Bharat* : Rewah, Amarkantak 3,500 ft. (1). *Madhya Pradesh* : Hoshangabad, Panchmarhi 3,500 ft. (1). *Madras* : Nilambur (3). *Uttar Pradesh* : Allahabad (1) ; Almora, Dhauli Ganga 9,520 ft. (1), Kali Valley 3,000 ft. (1) ; Chakrata, Bodyar (9) ; Dehra Dun, Dehra Dun (24), Kalsi (1), Mussoorie (1) ; Kumaon (1) ; Naini Tal, Bhowali (4).

Genus 5. *Heteropternis* Stål

7476. *Heteropternis respondens* Walker

India.—*Madras* : Nilambur (1). *Uttar Pradesh :* Almora, Kali Valley 3,000 ft. (1) ; Dehra Dun (8), Kalsi (1) ; Haldwani, Brahmdeo (1).

Genus 6. *Locusta* Linnæus

2523 & 7413. *Locusta migratoria* Linnæus

Phase *danica* (*solitaria* phase) :

India.—*Bihar* : Pusa (1). *Kashmir :* Jammu (1). *Uttar Pradesh :* Dehra Dun (1), Golatapper (1), Kalsi (1).

Extra-Indian.—ASIA : *Iraq* : Amara (1).

Genus 7. *Oedaleus* Fieber

6202. *Oedaleus abruptus* Thunberg

India.—*Madhya Pradesh* : Raipur, Birguri (2). *Madras* : N. Salem, Aiyur (1), Denkanikota (1) ; Nilambur, Mundakadavu (1) ; Nilgiris, Hill Grove 4,000 ft. (1). *Punjab* : Rawalpindi (1 hopper). *Uttar Pradesh* : Dehra Dun, Dehra Dun (6), Kalsi (3) ; Garhwal, Akeshwar (2), Gonda (4) ; Haldwani, Brahmdeo (1) ; Kumaon (1).

7394. *Oedaleus nigrofasciatus* De Geer

Extra-Indian.—ASIA : *Iraq* : Amara (3).

16295. *Oedaleus senegalensis* Krauss

India.—*Madras* : North Salem, Uduparani (1).

Genus 8. *Pternoscirta* Saussure

7406. *Pternoscirta cinctifemur* Walker

India.—*Assam* : Naga Hills (1). *Bengal* : Buxa (1). *Uttar Pradesh* : Dehra Dun (3).

Genus 9. *Pusa* Uvarov

10741. *Pusa rugulosa* Uvarov

India.—*Uttar Pradesh :* Kalagarh, Ratwadhab (1).

Genus 10. *Quiroguesia* Bolivar

7475. *Quiroguesia blanchardiana* Saussure

India.—? Bhuamalatti 4,000 ft. (1).

Genus 11. *Sphingonotus* Fieber

7477. *Sphingonotus cærulans* Linnæus

India.—*Uttar Pradesh* : Dehra Dun (1).

7404. *Sphingonotus indicus* Saussure

India.—*Uttar Pradesh* : Dehra Dun (4).

9721. *Sphingonotus longipennis* Saussure

India.—*Uttar Pradesh* : Dehra Dun (5).

7493. *Sphingonotus mecheriæ* Voss

Extra-Indian.—ASIA : *Iraq* : Amara (1).

Genus 12. *Trilophidia* Stål

9724. *Trilophidia annulata* Thunberg

India.—*Madras* : Nilambur (2) ; N. Salem, Aiyur (2). *Uttar Pradesh* : Dehra Dun (1).

18815. *Trilophidia* sp.

India.—*Madras* : Nilambur (1).

Subfamily 5. **PYRGOMORPHINAE**

Genus 1. *Atractomorpha* Saussure

2527. *Atractomorpha crenulata* Fabricius

India.—*Bihar* : Pusa (2). *Uttar Pradesh* : Dehra Dun (1, only tegmina).

18816. *Atractomorpha* sp.

India.—*Madras* : Nilambur, Arevacode (2), Nilambur (2) ; Nilgiris, Hill Grove 4,000 ft. (1),

Genus 2. *Aularches* Stål

2526. *Aularches miliaris* Linnæus

India.—*Madras* : Nilambur, Nedungayam (2) ; Nilambur (3) ; Shevaroy Hills 3,000 ft. (1). Unknown locality (4).

4480. *Aularches punctatus* Drury

India.—*Uttar Pradesh* : Dehra Dun, Dehra Dun (9), New Forest (1), Jhajra (1) ; Naini Tal, Bhowali (1).

Genus 3. *Chlorizeina* Brunner

17432. *Chlorizeina unicolor* Brunner

India.—*Burma* : Pyinmana, Yanaungmyin Reserve (1).

Genus 4. *Chrotogonus* Serville

6205. *Chrotogonus concavus* Kirby

India.—*Uttar Pradesh* : Gonda (1 hopper).

16293. *Chrotogonus* sp.

India.—*Madras* : North Salem, Aiyur (1). *Uttar Pradesh* : Almora (1) ; Dehra Dun (2).

Genus 5. *Orthacris* Bolivar

18817. *Orthacris* spp.

India.—*Madras* : N. Salem, Aiyur (22), Uduparani (3), Denkanikota (1). *Mysore & Coorg* : North Coorg, Fraserpet (6).

Genus 6. *Pœcilocerus* Serville

2538. *Pœcilocerus pictus* Fabricius

India.—*Bengal* : Shrupur (1). *Madras* : Coimbatore (1). *Rajasthan* : Ajmer State, Raoli 2,100 ft. (2). *Uttar Pradesh* : Etawah, Kalpi (1).

Genus 7. *Pyrgomorpha* Serville

7408. *Pyrgomorpha conica* Olivier

India.—*Uttar Pradesh* : Dehra Dun (1).

Extra-Indian.—ASIA : *Iraq* : Amara (2, damaged).

PART 6.—ORDER ORTHOPTERA (*concluded*) FAMILIES TETTIGONIIDÆ (= LOCUSTIDÆ) AND GRYLLIDÆ

BY M. L. ROONWAL and G. D. BHASIN

Family 5.—TETTIGONIIDÆ (= Locustidæ)

(Long-horned grasshoppers, Katydids)

The family Tettigoniidæ which contains the long-horned grasshoppers or Katydids, is very poorly represented in the collection, there being only 17 genera and 21 species, all Indian, except *Decticus albifrons* Fabr. which is from Iran (Persia). Out of the 24 subfamilies recognized by Kirby (*Synon. Catal. Orthoptera Brit. Mus.*, 2, 1906), 15 are Indian ; and of these 15, only 7 are represented in the F.R.I. collection. Karny and Candell (*Genera Insectorum, Orthoptera : Family Locustidæ*, 1908–12) follow a somewhat different subfamily classification, and recognize 21 subfamilies. The following genera are present (Kirby's classification), and there are no type-specimens :—

Subfam. 1. Gryllacrinæ : *Gryllacris* and *Schizodactylus.*

Subfam. 2. Conocephalinæ : *Conocephalus.*

Subfam. 3. Listroscelinæ : *Decolya* and *Xiphidiopsis.*

Subfam. 4. Pseudophyllinæ : *Morsimus* and *Sathrophyllia.*

Subfam. 5. Mecopodinæ : *Mecopoda.*

Subfam. 6. Phaneropterinæ : *Allodapa, Ducetia, Elimæa, Holochlora, Isopsera, Letana, Mirollia* and *Phaneroptera.*

Subfam. 7. Decticinæ : *Decticus.*

Family TETTIGONIIDÆ (Locustidæ)

Subfamily 1. GRYLLACRINAE

Genus 1. *Gryllacris* Serville

16300. *Gryllacris nivea* Brunner

India.—*Madras* : N. Salem, Aiyur (4), Jawalagiri (3) ; N. Arcot, Kottur (Vellore) 3,700 ft. (5).

16301. *Gryllacris vittata* Walker

India.—*Madras* : N. Salem, Aiyur (1), Jawalagiri (1).

16302. *Gryllacris* sp.

India.—*Mysore and Coorg* ; North Coorg, Fraserpet (1).

Genus 2. *Schizodactylus* Brulle

1136. *Schizodactylus monstrosus* Drury

India.—*Bihar* : Pusa (1). *Bengal* (3).

Subfamily 2. CONOCEPHALINAE

Genus 1. *Conocephalus* Thunberg

9861. *Conocephalus maculatus* Guillou.

India.—*Madras* : Nilambur (2).

Subfamily 3. LISTROSCELINAE

Genus 1. *Decolya* Bolivar

16297. *Decolya* sp.

India.—*Mysore and Coorg* : North Coorg, Fraserpet (1).

Genus 2. *Xiphidiopsis* Redtenbacher

16308. *Xiphidiopsis straminula* Walker

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (8) ; N. Salem, Aiyur (1), Jawalagiri (2). *Mysore and Coorg* : North Coorg, Fraserpet (1).

Subfamily 4. PSEUDOPHYLLINAE

Genus 1. *Morsimus* Stål

2541. *Morsimus carinatus* Walker

India.—*Bihar* : Pusa (1). *Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (7) ; N. Salem, Jawalagiri (5).

Genus 2. *Sathrophyllia* Stål

2539. *Sathrophyllia rugosa* Linnæus

India.—*Bihar* : Pusa (1). *Madras* : N. Salem, Aiyur (1), Jawalagiri (1). *Mysore and Coorg* : North Coorg, Fraserpet (2).

Subfamily 5. MECOPODINAE

Genus 1. *Mecopoda* Serville

2540. *Mecopoda elongata* Linnæus

India.—*Bengal* : Kuntimari (1) ; Lebong 300 ft. (1) ; Samsing 1,800 ft. (1) ; Tista 700 ft. (1). *Madhya Pradesh* : Mandla, Banjar (1). *Madras* : Nilambur (3). *Uttar Pradesh* : Dehra Dun (10).

Subfamily 6. PHANEROPTERINAE

Genus 1. *Allodapa* Brunner

16296. *Allodapa aliena* Brunner

India.—*Madras* : N. Arcot, Kottur (Vellor) 3,700 ft. (2) ; N. Salem, Aiyur (3), Denkanikota (2), Jawalagiri (5).

Genus 2. *Ducetia* Stål

9860. *Ducetia thymifolia* Fabricius

India.—*Madras* : Nilambur (2).

Genus 3. *Elimaea* Stål

16298. *Elimaea carinata* Brunner

India.—*Madras* : N. Arcot, Kottur (Vellor) 3,700 ft. (1) ; N. Salem, Aiyur (1), Jawalagiri (1), Nognoor (1). *Mysore and Coorg* : North Coorg, Fraserpet (4).

16299. *Elimæa securigera* Brunner

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (1) ; N. Salem, Aiyur (5), Jawalagiri (1). *Mysore and Coorg* : North Coorg, Fraserpet (1).

Genus 4. *Holochlora* Stål

16303. *Holochlora brevifissa* Brunner

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (3) ; N. Salem, Aiyur (1). *Mysore and Coorg* : North Coorg, Fraserpet (1).

16304. *Holochlora biloba* Stål

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (8) ; N. Salem, Aiyur (2), Jawalagiri (1).

Genus 5. *Isopsera* Brunner

16305. *Isopsera pedunculata* Brunner

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (1) ; N. Salem, Aiyur (2), Jawalagiri (1).

Genus 6. *Letana* Walker

16306. *Letana inflata* Brunner

India.—*Madras* : N. Salem, Aiyur (7), Jawalagiri (6), Uduparani (1). *Mysore and Coorg* : North Coorg, Fraserpet (2).

Genus 7. *Mirollia* Stål

16307. *Mirollia* sp.

India.—*Madras* : N. Salem, Aiyur (3), Jawalagiri (5).

Genus 8. *Phaneroptera* Serville

12590. *Phaneroptera roseata* Walker

India.—*Uttar Pradesh* : Dehra Dun (1 adult, 2 nymphs).

Subfamily 7. DECTICINAE

Genus 1. *Decticus* Serville

18810. *Decticus albifrons* Fabr.

Extra-Indian.—ASIA : *Iran* (*Persia*) : Lingah (1).

Family 6. GRYLLIDÆ

(Crickets, mole-crickets)

The family Gryllidæ, which comprises the crickets, mole-crickets, etc., is represented in the collection by 18 genera and 48 species, all Indian.

Of the 14 world subfamilies recognized by Kirby (*Synon. Catal. Orthoptera, Brit. Mus.*, **2**, 1906), 8 are represented in the collection. The systematic arrangement adopted here is that followed by Chopard (1936) in the following reference, with this difference that Tridactylinæ has been retained as a subfamily instead of being raised, as Chopard has done, to the rank of a separate family Tridactylidæ :—

CHOPARD, L. 1936. The Tridactylidæ and Gryllidæ of Ceylon.—*Spol. Zeylanica*, Colombo, **20**, pp. 9–87.

The following genera are present in the collection :—

Subfam. 1. Tridactylinæ : *Tridactylus*.

Subfam. 2. Gryllotalpinæ : *Curtilla*, *Gryllotalpa*.

Subfam. 3. Gryllinæ : *Brachytrypes*, *Gryllodes*, *Gryllulus*, *Gryllus*, *Gymnogryllus* and *Loxoblemmus*.

Subfam. 4. Nemobiinæ : *Pteronemobius*.

Subfam. 5. Trigonidiinæ : *Anaxipha*, *Cyrtoxipha*, *Metioche* and *Trigonidium*.

Subfam. 6. Mogoplistinæ : *Ornebius*.

Subfam. 7. Oecanthinæ : *Oecanthus*.

Subfam. 8. Podoscirtinæ : *Euscyrtus* and *Madasumma*.

Type-specimens.—The type-specimen of *Gryllulus flavipes* Chopard (a synonum of *Gryllulus blennus* Saussure) is present. There are two other specimens marked "types" as follows :—(*i*) 14726. *Tridactylus bilaminatus* Chopard ; and (*ii*) 14727. *Tridactylus curvipes* Chopard, both from Dehra Dun. These, however, are *not* types, as Dr. L. Chopard (of Paris), who had initially marked them as types several years ago, has recently informed us (in a letter dated 8th September 1950) that the two names are only *nomina nuda**, as he had once intended to describe them as new species but does not now intend to do so, having lost his descriptive notes. In the present *catalogue*, therefore, the two specimens have been listed under "*Tridactylus* sp."

Family 6. GRYLLIDÆ

Subfamily 1. TRIDACTYLINAE

Genus 1. *Tridactylus* Olivier

10006. *Tridactylus japonicus* Haan

India.—*Ceylon* : Hambantata (1). *Uttar Pradesh* : Dehra Dun (1).

14728. *Tridactylus marmoratus* Chopard

India.—*Uttar Pradesh* : Dehra Dun, Tons nadi (R. Tons) (1).

10004. *Tridactylus nigroæneus* Walker

India.—*Madras* : Nilambur, Nedungayam (1).

* Presumably he means "manuscript names". To our knowledge the names were never published even as ***nomina nuda;*** hence we regard them as "manuscript names" only.

10005. ***Tridactylus opacus*** Walker

India.—*Uttar Pradesh* : Dehra Dun, Kaligad (1).

10003. ***Tridactylus savignyi*** Guerin

India.—*Uttar Pradesh* : Dehra Dun (3).

14729. ***Tridactylus thoracicus*** Guerin

India.—*Bombay* : N. Kanara, Dandeli (1). *Madhya Pradesh* : S. Mandla, Motinala range (1). *Orissa* : Balasore (1).

18805. ***Tridactylus variegatus*** Latreille

India.—*Madhya Pradesh* : Mandla, Dindori (1).

14726. ***Tridactylus*** sp.

India.—*Uttar Pradesh* : Dehra Dun (1 damaged). Labelled as a type of *T. bimaculatus* Chopard, but is *not* a type—*vide* above.

14727. ***Tridactylus*** sp.

India.—*Uttar Pradesh* : Dehra Dun (1 damaged). Labelled as a type of *T. curvipes* Chopard, but is *not* a type, *vide* above.

Subfamily 2. GRYLLOTALPINAE

Genus 1. *Curtilla* Oken

18806. ***Curtilla himalayana*** Chopard

India.—*Bengal* : Darjeeling (1).

Genus 2. *Gryllotalpa* Latreille

2520. ***Gryllotalpa africana*** Beauvois

India.—*Bihar* : Pusa (1). *Bombay* : Karwar (1). *Madras* : Nilambur, Nedungayam (1). *Uttar Pradesh* : Dehra Dun (5).

14718. ***Gryllotalpa formosana*** Shiraki

India.—*Kashmir* : Langet (5).

14719. ***Gryllotalpa ornata*** Walker

India.—*Bengal* : Darjeeling, Rangirum 6,000 ft. (3).

14720. ***Gryllotalpa*** sp.

India.—*Andaman Is.* : N. Andamans, Bonington (2).

Subfamily 3. GRYLLINAE

Genus 1. *Brachytrypes* Serville

18809. ***Brachytrypes achatinus*** Stoll

India.—*Bengal* : Dacca (1), Damukdia (1).

14717. *Brachytrypes birmanus* Chopard

India.—*Bengal* : Tipperah (4).

10387. *Brachytrypes orientalis* Burmeister

India.—*Burma* : North Toungoo (1). *Uttar Pradesh* : Dehra Dun (3).

10008. *Brachytrypes portentosus* Lichtenstein

India.—*Bihar* : Pusa (1). *Bombay* : Bombay (1). *Burma* : North Toungoo, Pyonchaung (2). *Madras* : Nellore (1).

Genus 2. *Gryllodes* Saussure

10385. *Gryllodes sigillatus* Walker

India.—*Burma* : North Toungoo (1).

Genus 3. *Gryllulus* Uvarov

10012. **Gryllulus blennus* Saussure

SYN. **Gryllulus flavipes* Chopard

India.—*Uttar Pradesh* : Dehra Dun (1, *type* of *Gryllulus flavipes* Chopard) ; 1 other from Dehra Dun (locality doubtful).

10386. *Gryllulus configuratus* Walker

India.—*Bengal* : Calcutta (1). *Burma* : Pegu Yomas (1). *Rajasthan* : Marwar (2).

14721. *Gryllulus confirmatus* Walker

India.—*Uttar Pradesh* : Dehra Dun, Raipur forest (1).

10010. *Gryllulus conscitus* Walker

India.—*Uttar Pradesh* : Dehra Dun (2).

10015. *Gryllulus domesticus* Linnæus

India.—*Uttar Pradesh* : Dehra Dun (1).

10011. *Gryllulus longipennis* Saussure

India.—*Uttar Pradesh* : Dehra Dun (3).

10014. *Gryllulus mitratus* Burmeister

India.—*Burma* : North Toungoo (1). *Uttar Pradesh* : Dehra Dun (2).

10013. *Gryllulus testaceus* Walker

India.—*Uttar Pradesh* : Gorakhpur (1). Unknown locality (1).

10388. *Gryllulus* sp.

India.—*Rajasthan* : Marwar (1).

Genus 4. *Gryllus* Linnæus

2521. *Gryllus bimaculatus* De Geer

India.—*Bombay* : Bombay (2). *Madhya-Pradesh* : Katni (1). *Rajasthan* : Marwar (2 nymphs). *Uttar Pradesh* : Chakrata (1) ; Dehra Dun (2), Mussoorie (1) ; Naini Tal, Bhim Tal (1).

Genus 5. *Gymnogryllus* Saussure

10009. *Gymnogryllus angustus* Saussure

India.—*Uttar Pradesh* : Dehra Dun (1).

2408. *Gymnogryllus erythrocephala* Serville

India.—*Bombay* : N. Kanara (2) ; S. D. Kanara (2) ; Karwar (1). *Madras* : N. Salem, Uduparani (1). *Uttar Pradesh* : Dehra Dun (5).

14722. *Gymnogryllus humeralis* Walker

India.—*Bombay* : Karwar (1) ; N. Kanara (3). *Madras* : Lower Cocanada, Godavari (3).

Genus 6. *Loxoblemmus* Saussure

10016. *Loxoblemmus detectus* Serville

India.—*Uttar Pradesh* : Dehra Dun (4).

14723. *Loxoblemmus equestris* Saussure

India.—*Bengal* : Tipperah (3). *Madras* : Arcot (1). *Uttar Pradesh* : Dehra Dun (2).

Subfamily 4. NEMOBIINAE

Genus 1. *Pteronemobius* Jacobson and Bianchi

10007. *Pteronemobius fascipes* Walker

India.—*Uttar Pradesh* : Dehra Dun (4).

Subfamily 5. TRIGONIDIINAE

Genus 1. *Anaxipha* Saussure

18808. *Anaxipha longipennis* Serville

India.—*Ceylon* : Maskeliya (1).

Genus 2. *Cyrtoxipha* Brunner

10740. *Cyrtoxipha* sp.

India.—*Burma* : Insein, Okkan reserve (1).

Genus 3. *Metioche* Stål

18804. *Metioche humbertiana* Saussure

India.—*Madras* : Bangalore (1).

16310. *Metioche unicolor* Chopard

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (2) ; N. Salem, Jawalagiri (1). *Mysore and Coorg* : North Coorg, Fraserpet (6).

Genus 4. *Trigonidium* Rambur

18807. *Trigonidium cicindeloides* Rambur

India.—*Andaman Is.* : Port Blair (1).

Subfamily 6. MOGOPLISTINAE

Genus 1. *Ornebius* Guerin

16309. *Ornebius guerini* Bolivar

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (5) ; N. Salem, Aiyur (4), Jawalagiri (2). *Mysore and Coorg* : North Coorg, Fraserpet (7).

Subfamily 7. OECANTHINAE

Genus 1. *Oecanthus* Serville

16311. *Oecanthus bilineatus* Chopard

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (2), N. Salem, Aiyur (4), Jawalagiri (6).

Subfamily 8. PODOSCIRTINAE

Genus 1. *Euscyrtus* Guerin

10739. *Euscyrtus concinnus* Haan

India.—*Burma* : Insein, Okkan reserve (3).

Genus 2. *Madasumma* Walker

14724. *Madasumma irrorata* Saussure

India.—*Madhya Pradesh* : S. Mandla, Motinala (1). *Uttar Pradesh* : Dehra Dun (1). Unknown locality (1).

14725. *Madasumma marginipennis* Guerin

India.—*Uttar Pradesh* : Dehra Dun (2).

16312. *Madasumma varipennis* Walker

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (5) ; N. Salem, Aiyur (1) ; Jawalagiri (2). *Mysore and Coorg* : North Coorg, Fraserpet (1).

16313. *Madasumma ventralis* Walker

India.—*Madras* : N. Arcot, Kottur (Vellore) 3,700 ft. (1) ; N. Salem, Jawalagiri (1).

16314. *Madasumma* sp.

India.—*Madras* : N. Salem, Jawalagiri (3).

PART 7—ORDER DERMAPTERA

BY M. L. ROONWAL and G. D. PANT

Order 5. DERMAPTERA

(Earwigs, etc.)

The order Dermaptera, containing the earwigs, is represented in the collection by 21 genera and 36 species, belonging to the suborder Forficulina, all of whose 6 families are represented in our collection ; all species are Indian. The remaining 2 suborders, *viz.*, the Arixenia and the Hemimerina, are unrepresented. No type-specimens are present. It will thus be seen that the collection is very poor even in the Indian species, and representatives of the unrepresented species will be welcomed.

The following 21 genera are represented :—

Superfamily 1. LABIDUROIDEA

Fam. 1. PYGIDICRANIDAE : *Acrania*, *Diplatys* and *Echinosoma.*

Fam. 2. LABIDURIDAE : *Anisolabis*, *Forcipula*, *Homœolabis*, *Labidura*, *Nala* and *Psalis.*

Superfamily 2. APACHYOIDEA

Fam. 3. APACHYIDAE : *Apachyus.*

Superfamily 3. FORFICULOIDEA

Fam. 4. FORFICULIDAE : *Allodahlia*, *Anechura*, *Elaunon*, *Eudohrnia*, *Forficula*, *Homotages*, *Hypurgus* and *Pareparchus.*

Fam. 5. CHELISOCHIDAE : *Proreus.*

Fam. 6. LABIIDAE : *Labia* and *Spongovostox.*

The generic and specific names are largely those given in following two references, together with some recent changes :—

BURR, M. 1910. *The Fauna of British India, including Ceylon and Burma. Dermaptera (Earwigs)* ; xviii + 217 pp., 10 pls. — London (Taylor & Francis Ltd.).

CHOPARD, L. 1922. *Faune de France. 3. Orthoptéres et Dermaptéres.* 212 pp.—Paris (P. Lechevalier).

5. DERMAPTERA

Suborder 1. *FORFICULINA*

(Earwigs)

Superfamily 1. LABIDUROIDEA

Family 1. PYGIDICRANIDÆ

Genus 1. *Acrania* Burr

4516. *Acrania picta* Guérin

India.—*Bengal* : Calcutta (1). *Madras* : N. Salem, Aiyur (1 ♂).

Genus 2. *Diplatys* Serville

6075. *Diplatys falcatus* Burr

India.—*Uttar Pradesh* : Kumaon, Shamkhet (2).

16223. *Diplatys* sp.

India.—*Madras* : N. Arcot : Kottur (Vellore) 3,700 ft. (1) ; N. Salem, Jawalagiri (3). *Mysore and Coorg* : North Coorg, Fraserpet (1).

Genus 3. *Echinosoma* Serville

6076. *Echinosoma parvulum* Dohrn

India.—*Uttar Pradesh :* Dehra Dun, Kansrao (1), Golatapper (1).

4508. *Echinosoma sumatranum* Haan

India.—*Burma* : Tenasserim (1) ; Tharrawaddy (1 nymph). *Uttar Pradesh* : Bankatti (Kheri Forest) (1) ; Dehra Dun, Jhajra (2) ; Kumaon, Almora (1), Bhowali (1).

Family 2. LABIDURIDÆ

Genus 1. *Anisolabis* Fieber

2499. *Anisolabis annulipes* Lucas

India.—*Bihar* : Muzaffarpur (2). *Uttar Pradesh* : Dehra Dun (9).

Genus 2. *Forcipula* Bolivar

2176. *Forcipula decolyi* Bormans

India.—*Bengal* : Kurseong 5,000 ft. (1).

6072. *Forcipula pugnax* Kirby

India.—*Madhya Pradesh* : Bhandara, Nawegaon Bund (2). *Uttar Pradesh* : Dehra Dun, Lachiwala (7) ; *Kumaon*, Bhowali (10), Dharmoti (1), Sattal (2), Someswar (1).

2175. *Forcipula trispinosa* Dohrn

India.—*Nepal* : Soondrijal (1). *Uttar Pradesh* : Dehra Dun (2).

Genus 3. *Homœolabis* Borelli

16224. *Homœolabis maindroni* Borelli

India.—*Madras* : N. Salem, Jawalagiri (1).

Genus 4. *Labidura* Leach

2501. *Labidura bengalensis* Dohrn

India.—*Bihar* : Pusa (1). *Uttar Pradesh* : Allahabad (2) ; Dehra Dun (11).

2174A. *Labidura riparia* Pallas

India.—*Madhya Pradesh* : Bhandara, Nawegaon Bund (6) ; Sonder (1). *Punjab* : Simla (1). *Uttar Pradesh* : Dehra Dun (3) ; Kumaon, Bhowali (1). Unknown locality (2).

2174B. *Labidura riparia* var. *inermis* Brunner

India.—*Uttar Pradesh* : Dehra Dun (3).

Genus 5. *Nala* Zacher

4510 (& 2500). *Nala lividipes* Dufour

India.—*Bihar* : Pusa (1). *Madhya Pradesh* : Bhandara, Sonder (1). *Madras* : N. Salem, Uduparani (2). *Uttar Pradesh* : Dehra Dun, Dehra Dun (4), Lachiwala (1).

Genus 6. *Psalis* Serville

6074. *Psalis dohrni* Kirby

India.—*Uttar Pradesh* : Kumaon, Almora (1), Bhowali (6), Takula (1).

Superfamily 2. APACHYOIDEA

Family 3. APACHYIDÆ

Genus 1. *Apachyus* Serville

9816. *Apachyus pascoi* Kirby

India.—*Assam* : Cachar, Haflong (1) ; Sibsagar, Nambor Resv. (1).

Superfamily 3. FORFICULOIDEA

Family 4. FORFICULIDÆ

Genus 1. *Allodahlia* Verhœff

2178. *Allodahlia coriacea* Bormans

India.—*Uttar Pradesh* : Kumaon, Bhimtal 4,500 ft. (1).

6073. *Allodahlia macropyga* Westwood

India.—*Uttar Pradesh* : Dehra Dun, Jaunsar (Chakrata) (7) ; Kumaon, Almora (2), near Bhowali (1), Dharmoti (5), Takula (3).

Genus 2. *Anechura* Scudder

9817. *Anechura zubovskii* Semenoff

India.—*Uttar Pradesh* : Dehra Dun, Chullikhud (Chakrata) 8,000 ft. (1).

Genus 3. *Elaunon* Burr

4512. *Elaunon bipartitus* Kirby

India.—*Bengal* : Darjeeling, Lebong 5,000 ft. (1). *Madras* : N. Salem, Aiyur (2), Daverbetta (2), Jawalagiri (1 ♂ 1 ♀ , 4). *Mysore and Coorg* : North Coorg, Fraserpet (2). *Uttar Pradesh* : Dehra Dun (1) ; Kumaon, Almora (4) , Dinapani (1).

Genus 4. *Eudohrnia* Burr

2505. *Eudohrnia metallica* Dohrn

India.—*Assam* : Nongpoh (Khasi Hills) (1).

Genus 5. *Forficula* Linnæus

4506. *Forficula aceris* Burr

India.—? N. India (1 ♂).

4505. *Forficula beelzebub* Burr

India.—*Uttar Pradesh* : Dehra Dun, Kudri (Jaunsar—Chakrata) ; Kumaon, Almora (40), Bhowali (1), Binsar (1).

16225. *Forficula greeni* Burr

India.—*Madras* : N. Salem, Aiyur (1), Jawalagiri (1).

16226. *Forficula ornata* Bormans

India.—*Madras* : N. Salem, Aiyur (1 ♂), Jawalagiri (1 ♀ , 1).

4514. *Forficula schlagintweiti* Burr

India.—*Punjab* : Simla (Catchment Area) (1).

Genus 6. *Homotages* Burr

2177. *Homotages feæ* Bormans

India.—*Nepal* : Chitlong (1). *Uttar Pradesh* : Dehra Dun, Kuriala (Jaunsar—Chakrata) (3), Mussoorie (2) ; Kumaon, Airadeo (1), Bhowali (1), Dharmoli (2).

Genus 7. *Hypurgus* Burr

4513. *Hypurgus humeralis* Kirby

India.—*Uttar Pradesh* : Dehra Dun (4).

Genus 8. *Pareparchus* Burr

16227. *Pareparchus pelvimeter* Hebard

India.—*Mysore & Coorg* : North Coorg, Fraserpet (2 ♂ ♂ , 1 ♀ , 8).

Family 5. CHELISOCHIDÆ

Genus 1. *Proreus* Burr

2503. *Proreus melanocephalus* Dohrn

India.—*Bihar* : Pusa (1).

2502. *Proreus simulans* Stål.

India.—*Bihar* : Pusa (1).

Family 6. LABIIDAE

Genus 1. *Labia* Leach

4511. *Labia curvicauda* Motschulsky

India.—*Uttar Pradesh* : Bankatti (Kheri Forests) (1) ; Dehra Dun, Jhajra (1), Karwapani (2), Thano (1).

4515. *Labia mucronata* Stål

India.—*Burma* : Tennaserim (3).

Genus 2. *Spongovostox Burr*

4517. *Spongovostox luteus* Bormans

India.—*Burma* : Katha (1).

4507. *Spongovostox semiflavus* Bormans

India.—*Burma* : Tharrawaddy (2). *Uttar Pradesh* : Dehra Dun, Lachiwala (2).

Suborder II. *ARIXENINA*

This suborder contains a single family, Arixeniidæ, which in its turn, contains a single genus, *Arixenia* Jordan, having two known species. It is not represented in the F.R.I. Collection.

Suborder III. *HEMIMERINA*

This suborder comprises a single family, Hemimeridæ, which contains a single monospecific genus, *Hemimerus* Walker. It is not represented in the F.R.I. Collection.

PART 8.—ORDER PLECOPTERA

No specimens are present.

Previous Parts of this Catalogue

PART 1.—Introduction. (*By M. L. Roonwal*).—*Indian Forester*, Dehra Dun, **76** (11) 1950, pp. 498–502.

PART 2.—Subclass Apterygota. (*By M. L. Roonwal and G. D. Bhasin*).—*Ibid.*, pp. 502–503.

PART 3.—Subclass Pterygota, Order Orthoptera (in part), Family Blattidæ. (*By M. L. Roonwal and G. D. Pant*).—*Ibid.*, pp. 503–505.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*b*) (Analytical Method)

(*Continued from the* Indian Forester, *March, 1951, page 205*)

(S) Inference of max. positive and max. negative shears on the Howe truss :—

(*a*) Max. Positive Shears :

Condition of loading for max. positive shears are fully explained in para (K) page 192, *Indian Forester* of March, 1951 for the various panels of the Howe truss.

However, for any one panel, if all the other panel loadings are not considered [e.g., say for the 1st panel—Refer Fig. 100 and para (K) page 192, *Indian Forester*, March, 1951—if L_1 to L_7 are not loaded, but say L_1, L_2, L_3, L_4 and L_5 only are loaded, even then the shear in panel one, would be positive though not maximum—i.e., the shear although positive will not be of maximum value —].

Thus max. positive stress in any one member (i.e., either a diagonal or a vertical of the Howe truss) corresponds to the force that would actually act when the truss is so loaded as to give *Max. Positive Shear* for that particular panel in which that member (either a diagonal or a vertical) occurs.

(*b*) Max. Negative Shears :

Similarly max. negative stress in a vertical or a diagonal corresponds to the actual force in the member when the truss is so loaded as to give max. negative shear condition for that particular panel in which that vertical member (or that diagonal member) occurs [Refer para (L) page 196, *Indian Forester* of March, 1951].

(*c*) Consideration of max. negative live load stresses :

(1) In case of bottom and top booms, the question of max. negative live load stresses does not arise because no position of live load on bridge will cause a reversal of stress in these members. The bottom and top booms always remain in tension and compression respectively.

(2) The numerical value of Max. Shear in a panel governs the stresses of the diagonal or the vertical member in that panel [Refer Fig. 78, stage III and para (K) Part V(*a*), *Indian Forester*, January, 1951].

(3) Shear in certain panels change sign with different conditions of live loadings [Refer para (K)(1) page 192 and (L)(2) page 196 also para (M)(2) and (M)(3) page 198 of Part V(*b*), *Indian Forester*, March, 1951].

(4) Hence max. negative stresses are of all significance in arriving at finding the stresses in the diagonals and vertical members because the reversal of shear has a compensatory effect on the net stress, i.e., resultant stress

in any one member, as will be clear from calculation below [Refer para (T) condition (*c*)(6) below].

(5) If all the vertical members and diagonals were to be designed separately for economical design, these stresses, i.e., max. negative stresses [occurring due to reversal of shear as in para (3) above] would be very useful for producing resultant stresses, (i.e., net stresses) of low value and hence smaller sections of members for economical design.

(6) In our case of Forest Designs of Bridges,

(i) to be on the safe side, and

(ii) for quick design,

all diagonals and verticals are designed on the max. value of stresses in any one of the respective members, i.e., diagonals or verticals. [Refer para (M), Part V(*a*), page 48, *Indian Forester*, January, 1951].

(7) Thus para (3) above is of academic interest as far as our forest design is concerned. However, it clearly brings out the actual role of stresses, i.e.,

(*a*) max. positive,

(*b*) max. negative,

in the various members.

(T) Determination of Max. Negative Live Load Stresses in the members (vertical and diagonals only) of Howe truss with

(i) all the panel dead loads acting but

(ii) under different conditions of panel live loadings.

Condition (*a*) :—Fig. 112.

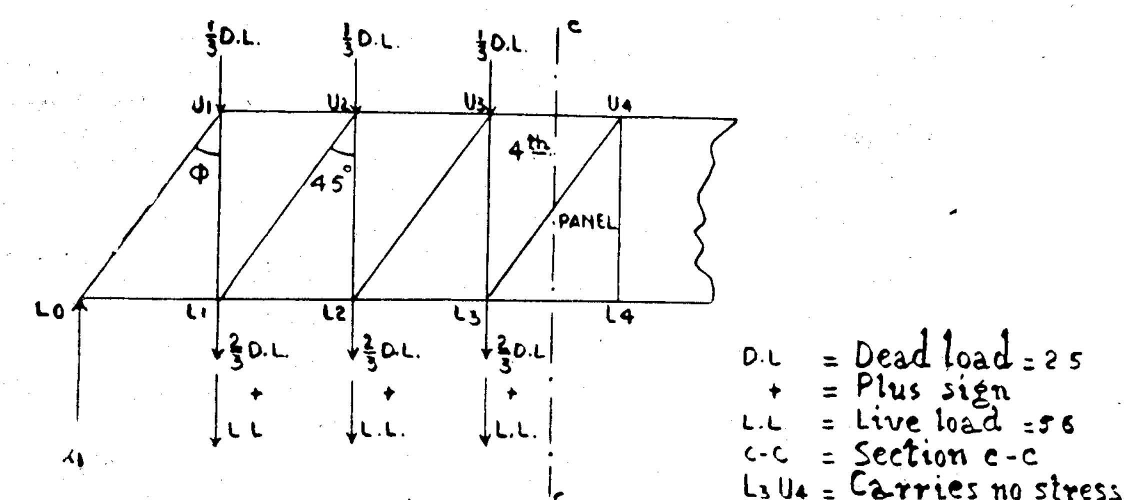


Fig. 112

To find max. negative live load stress for vertical member $U_3 L_3$ when

(i) panel live loads are placed at L_1, L_2 and L_3 only but

(ii) panel dead loads are all there

(1) Consider section C — C in panel 4 and loads to the left of the section. [Refer Fig. 112).

Note.—Max. negative live load stresses are calculated by consideration of max. negative shears, the condition for which is that we have to consider all loadings to the left of the section under consideration. [Refer para (J)(4), Rule 6 (*b*), page 141, Part V(*b*), *Indian Forester*, February, 1951].

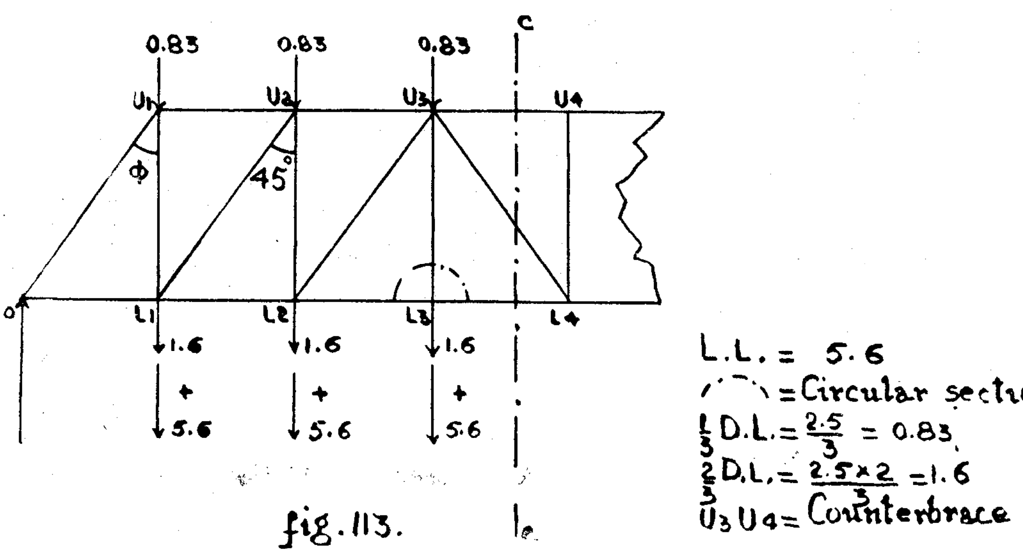
(2) Max. negative live load shear in panel 4 or section C — C is [Refer para (M)(1), page 198, *Indian Forester*, March, 1951]

$V_{l_4} = - 4 \cdot 2$ in thousands of lb.

(3) Max. Dead load shear in panel 4 or section C — C is [Refer para (M)(1), page 198, *Indian Forester*, March, 1951].

$V_{d_4} = + 1 \cdot 30$ in thousands of lb.

Fig. 113.



(4) From paras (2) and (3) above we can say that panel 4 satisfies the requirement of a counter-brace L_4 U_3 instead of a diagonal U_4 L_3 which carries no stress when condition of dead and live panel loads is as in para (T) condition (*a*) above.

(5) ∴ Stress in U_3 L_3 due to condition (*a*) of loadings is equal to (considering a circular section and equating opposite forces—Refer procedure in para (G) (2)(*d*), page 138, *Indian Forester*, February, 1951.

Sum of dead panel load and live panel load at point L_3

$= 1 \cdot 60 + 5 \cdot 6$

$S_{U_3L_3} = 7 \cdot 20$ in thousands of lb. and nature of stress is tensile.

Condition (*b*) :—Fig. 114.

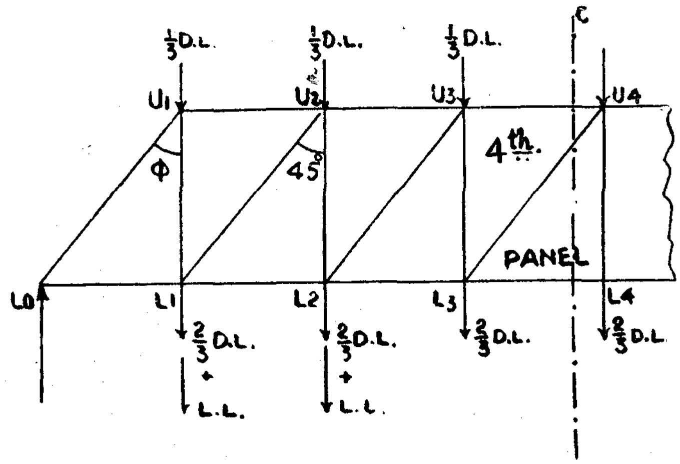


fig. 114.

To find max. negative live load stress for vertical member U_3 L_3 when

(i) panel live loads are placed at L_1 and L_2 only but

(ii) panel dead loads are all there.

(1) Consider section C — C in panel 4 and loads to the left of it (Refer Fig. 114).

(2) Max. negative live load shear in panel 4 or section C — C is [Refer para (M)(1), page 198, *Indian Forester*, March, 1951].

$V_{14} = V_{13} = -2 \cdot 1$ in thousands of lb.

[*Note*.—V_{14} here is equal to V_{13} because there is no live load beyond point L_2 as per condition (*b*) above].

(3) Max. dead load shear in panel 4 or section C — C is [Refer para (M)(1), page 198, *Indian Forester*, March, 1951]

$V_{d_4} = +1 \cdot 30$ in thousands of lb.

(4) Fig. 115.

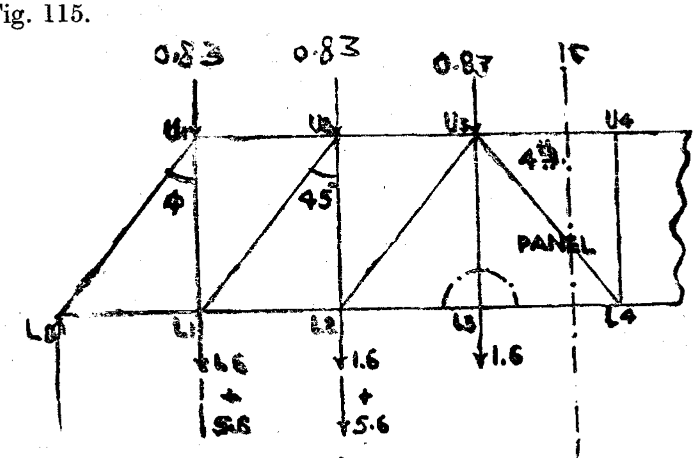


fig. 115.

From paras (2) and (3) above we can say that panel 4 still satisfies the requirement of a counter brace L_4 U_3 instead of diagonal U_4 L_3 which carries no stress when condition of dead and live panel loads is as in para (T) condition (*b*) above, and Fig. 115.

(5) ∴ Stress in U_3 L_3 due to condition (*b*) of loadings is equal to (considering a circular section and equating opposite forces as before.

Sum of dead panel load and live panel load at point L_3

$= 1 \cdot 60 + 0$ [*Note*.—There is no live panel load at point L_3 as per condition (*b*)].

∴ $S_{U_3L_3} = 1 \cdot 60$ in thousands of lb. and nature of stress is tensile.

Condition (*c*) :—Fig. 116.

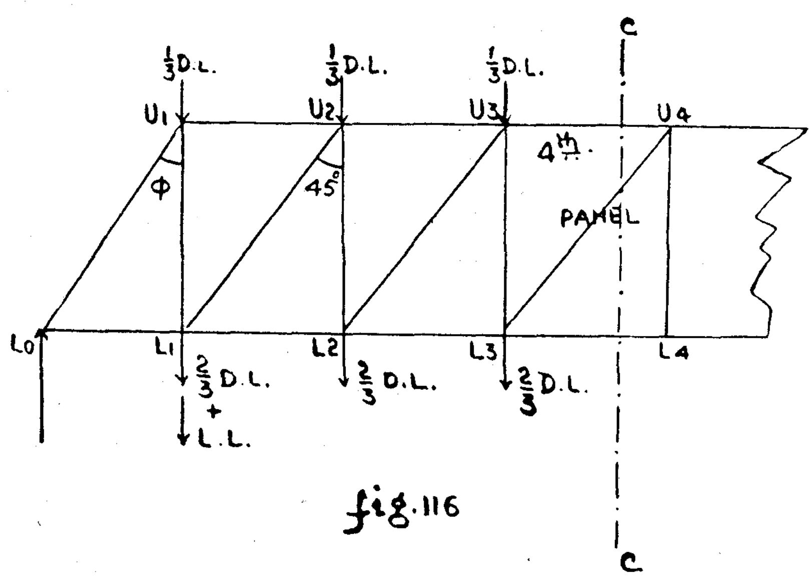


fig. 116

To find max. negative live load stress for vertical member U_3 L_3 when

(i) panel live loads are placed at L_1 only but

(ii) panel dead loads are all there.

(1) Consider section C — C in panel 4 and loads to the left of it (Refer Fig. 116).

(2) Max. negative live load shear in panel 4 or section C — C is [Refer para (M)(1) page 198, *Indian Forester*, March, 1951].

$V_{l_4} = V_{l_3} = V_{l_2} = -0 \cdot 7$ in thousands of lb.

[*Note*.—$V_{l_4} = V_{l_3} = V_{l_2}$ because there is no live load beyond point L_1 as per condition (*b*) above].

(3) Max. dead load shear in panel 4 or section C — C is [Refer para (M)(1), page 198, *Indian Forester*, March, 1951].

$V_{d_4} = +1 \cdot 3$ in thousands of lb.

(4) Fig. 117.

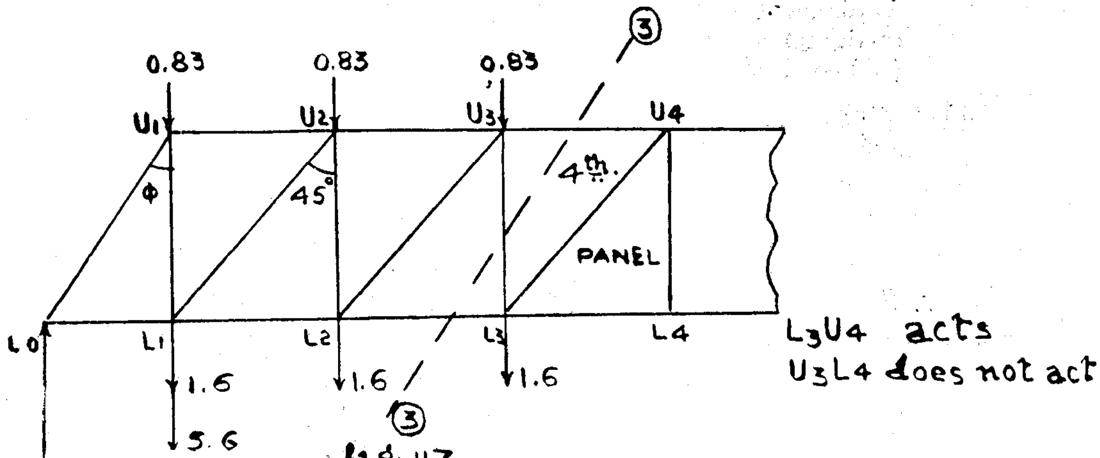


fig. 117.

From paras (2) and (3) above we can say that panel 4 no more satisfies the requirement of a counter-brace. Therefore, diagonal L_3 U_4 carries stress and counter-brace U_3 L_4 carries zero stress when condition of dead and live panel loads is as in para (T) condition (*b*) and Fig. 117.

(5) ∴ Stress in U_3 L_3 cannot be found by taking a circular section but can be derived by taking section 3 — 3 to cut only three members [Refer procedure in para (G)(2)(*c*) page 138 *Indian Forester*, February, 1951].

(*a*) ∴ $S_{U_3L_3}$ due to panel dead loads

= Max. positive dead load shear in panel 3 — panel dead load at point U_3.

∴ $S_{U_3L_3}$ due to panel dead loads

= + 3·95 — 0·83 [Refer para (M)(1) page 198 Part V(*b*)].

= + 3·12 in thousands of lb.

= + 3120 lb.

(*b*) $S_{U_3L_3}$ due to panel live load

= Live load shear along section 3 — 3

[*Note*.—because max. negative stress in any vertical (here $S_{U_3L_3}$) due to panel live load equals max. negative live load shear in the panel in which the vertical member occurs or exists].

= Max. negative shear in panel 3

= ,, ,, ,, in panel 2.

[*Note*.—Because live load is only at panel point L_1 as per condition (*c*)].

∴ Max. negative stress in

$S_{U_3L_3}$ due to panel live load

= — 0·7 in thousands of lb. and nature of stress is compressive

= — 700 lb.

(6) (i) Hence from para (T) condition (*c*)(5) (*a*) and (*b*) we conclude that the compressive stress of 700 lb. in U_3 L_3 (due to panel live load at L_1 only) occurs at the same time as the dead load tensile stress of 3070 lb. in U_3 L_3.

(ii) Also from para (T) conditions (*a*), (*b*) and (*c*) we find that minimum live load stress in

U_3 L_3 = 700 lb. and is compressive when panel live load is at point L_1 only.

(iii) Thus we find that vertical U_3 L_3 does not in all cases of live load come under a tensile force but actually becomes compressive under condition (*c*) of live loading (i.e., there is reversal of stress).

(U) Condition (*a*) :—Fig. 118.

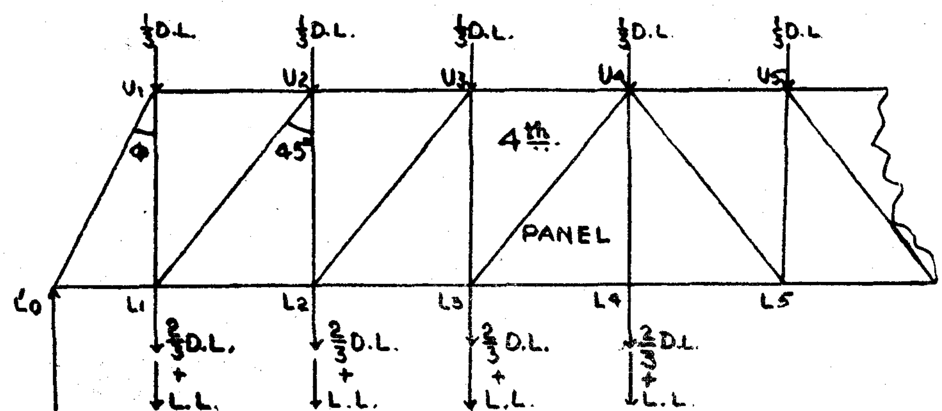


fig. 118.

To find max. negative live load stress for vertical member U_4 L_4 when

(i) panel live loads are placed at

L_1, L_2, L_3 and L_4 only but

(ii) panel dead loads are all there.

(1) Considering panel 4 we have

(*a*) Dead load shear in 4th panel = + 1·30....[Refer para (M)(1), Part V(*b*)].

(*b*) Max. negative live load shear in 4th panel = − 4·2 [Refer para (M)(1), Part V(*b*)].

Thus from above, the condition of counter-brace is satisfied and hence member L_3 U_4 is not acting but instead the counter-brace U_3 L_4 is acting.

Fig. 119.

(2) Considering panel 5 we have

(*a*) Dead load shear in panel 5 = − 1·30....[Refer para (M)(1), Part V(*b*)].

(*b*) Max. negative live load shear in panel 5 = − 7·0....[Refer para (M)(1), Part V(*b*)].

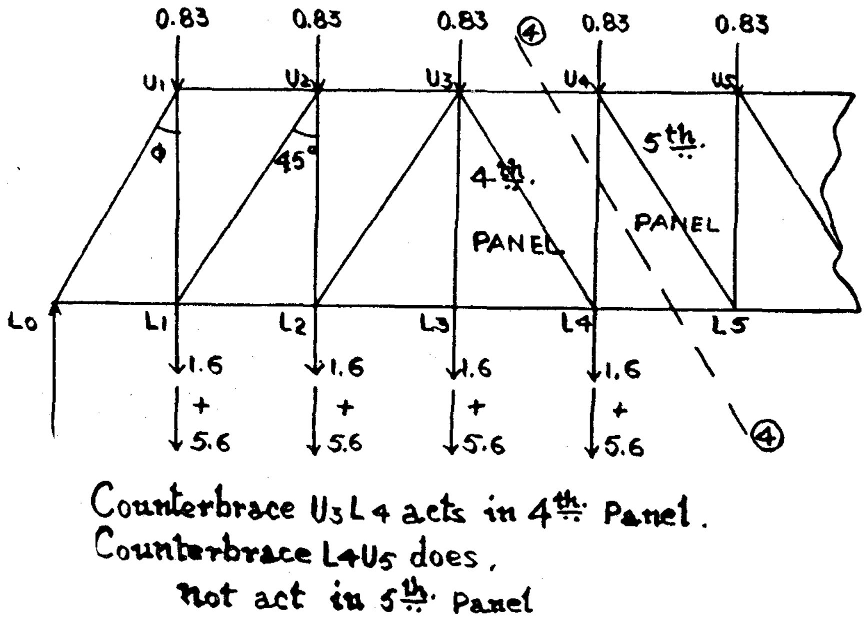


fig. 119

Thus from the above, conditions of counter-brace are not satisfied in panel 5 and hence diagonal U_4 L_5 acts in the 5th panel and not the counter-brace L_4 U_5.

(3) Members of the truss under actual stresses are shown in Fig. 119, redundent members like L_3 U_4 and L_4 U_5, are not shown.

(4) Considering section (4) — (4) in Fig. 119 we have

(*a*) Dead load stress in U_4 L_4 is equal to max. positive dead load at point U_4.
i.e., $S_{U_4L_4}$ due to panel dead loads $= -1 \cdot 30 + 0 \cdot 83$....Fig. 119
$= -0 \cdot 47$ in thousands of lb.

(*b*) Max. negative live load stress in U_4 L_4 = Max. negative live load shear in 5th panel
$= -7 \cdot 0$...[Refer para (M)(1), Part V(*b*)].

From para (4)(*a*) and (*b*) above we see that both the stresses are tensile (of the same sign), i.e., there is no reversal of stress due to condition (*a*) of live loadings.

Condition (*b*) :—Fig. 120.

To find max. negative live load stress for vertical member U_4 L_4 when

(i) panel live loads are placed at
L_1, L_2 and L_3 only but

(ii) panel dead loads are all there.

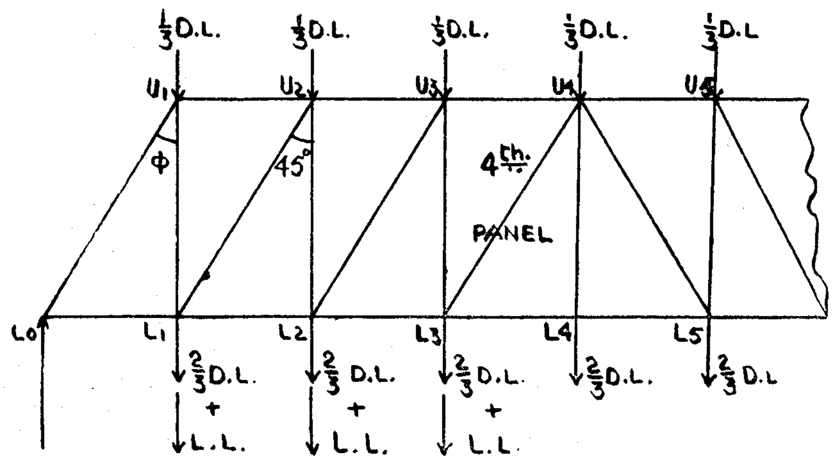


fig. 120.

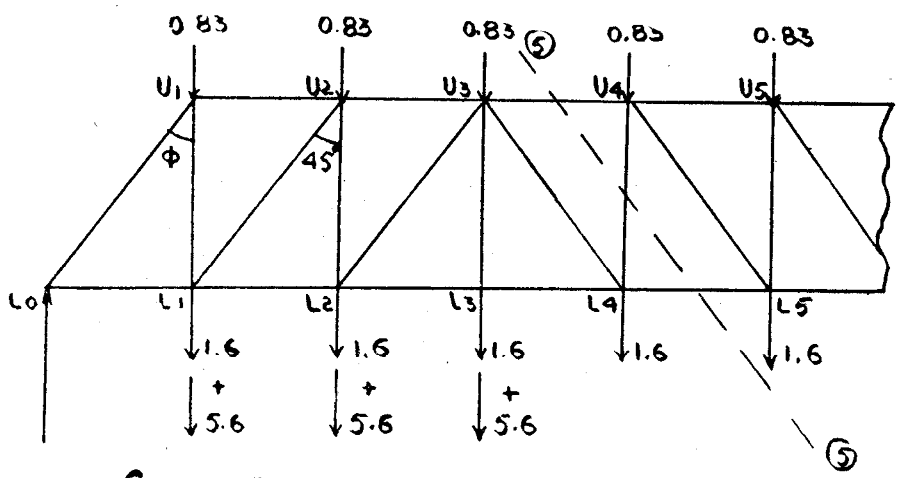
(1) Considering panel 4 we have

(a) Max. positive dead load shear $= +1 \cdot 30$....[Refer para (M)(1)].

(b) Max. negative live load shear $= -4 \cdot 2$....[Refer para (M)(1)].

Thus we see that counter-brace U_3 L_4 is acting and the diagonal L_3 U_4 has no stress in panel 4.

(2) Fig. 121.



Counterbrace U3 L4 acts in 4th PANEL
Diagonal U4 L5 acts in 5th PANEL.

fig. 121.

Similarly considering panel 5 we could deduce that diagonal U_4 L_5 acts in the 5th panel and condition of counter-brace in panel 5 is not satisfied.

(3) Considering section (5) — (5) in Fig. 121 we have

(*a*) Dead load stress in U_4 L_4 is equal to max. positive dead load shear in 5th panel plus panel dead load at point U_4.

i.e., $S_{U_4L_4}$ due to panel dead loads $= -1 \cdot 3 + 0 \cdot 83$

$= -0 \cdot 47$ in thousands of lb.

(*b*) Max. negative live load stress in U_4 L_4 = Max. negative live load shear in 5th panel.

= Max. negative live load shear in 4th panel because there is no live load at point L_4 as per condition (*b*) of live loadings.

$= -4 \cdot 2$ in thousands of lb.

(4) From para 3(*a*) and (*b*) above we see that both the stresses are tensile (i.e., of the same sign), i.e., there is no reversal of stress due to condition (*b*) of live loadings.

Condition (*c*) :—Fig. 122.

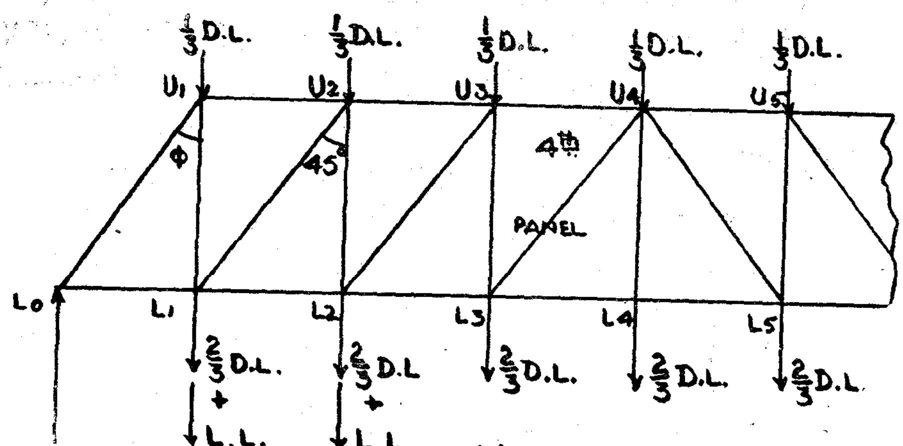


Fig. 122.

To find max. negative live load stress for vertical member U_4 L_4 when

(i) panel live loads are placed at L_1 and L_2 only but

(ii) panel dead loads are all there.

(1) Considering panel 4 we have

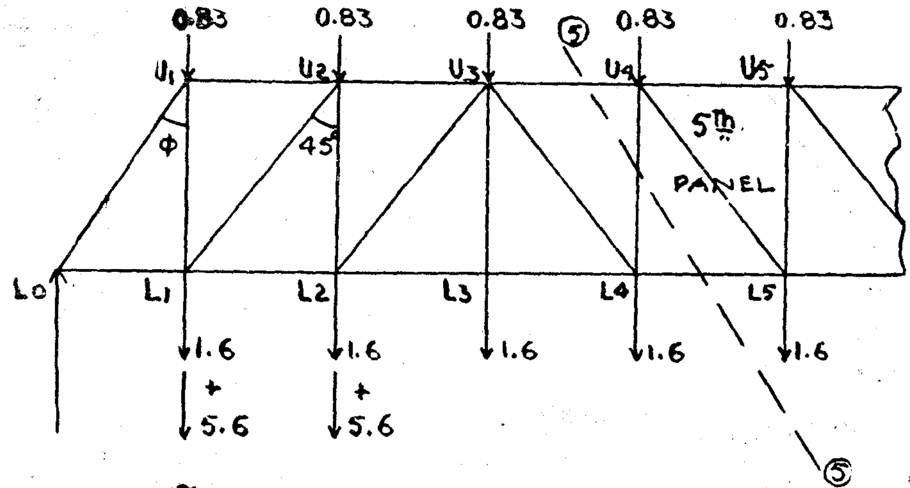
(*a*) Max. positive dead load shear $= +1 \cdot 30$ in thousands of lb.

(*b*) Max. negative live load shear = max. negative live load shear in 3rd panel because there is no live load at point L_3 by condition (*c*) of live loading.

$= -2 \cdot 1$.... [Refer para (M)(1) Part V(*b*)].

Thus we see that counter-brace U_3 L_4 is acting in the 4th panel and the diagonal L_3 U_4 has no stress.

(2) Fig. 123.



Counterbrace U3L4 acts in 4th PANEL.
Diagonal U4L5 acts in 5th PANEL

Fig. 123.

Similarly considering panel 5 we could deduce that diagonal U_4 L_5 acts and condition of counter-brace in panel 5 is not satisfied.

(3) Considering section 5 — 5 in Fig. 123 we have

(*a*) Dead load stress in U_4 L_4 is equal to max. dead load shear in 5th panel given by para (M)(1) Part V(*b*) plus panel dead load at point U_4 i.e., $S_{U_4L_4}$ due to panel dead load $= -1 \cdot 3 + 0 \cdot 83$

$= -0 \cdot 47$ in thousands of lb.

(*b*) Max. negative live load stress in U_4 L_4 = Max. negative live load shear in 5th panel

= Max. negative live load shear in 3rd panel because there is no live load at points L_4 and L_3 as per condition (*c*) of live loadings

$= -2 \cdot 1$ in thousands of lb.

(4) From para 3(*a*) and (*b*) above we see that both the stresses are tensile (i.e., of the same sign), i.e., there is no reversal of stress due to condition (*c*) of live loadings.

Condition (*d*) :—Fig. 124.

To find max. negative live load stress for vertical member U_4 L_4 when

(i) panel live loads are placed at point L_1 only but

(ii) panel dead loads are all there.

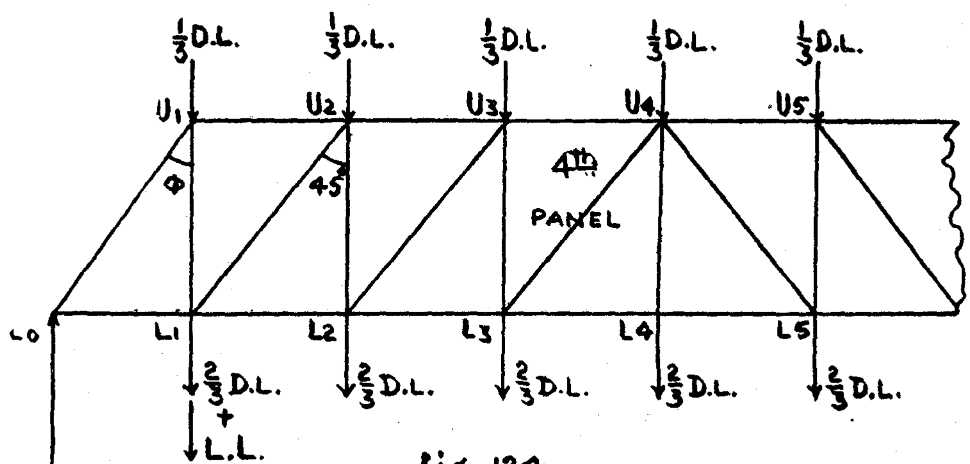


fig. 124.

(1) Considering panel 4 we have

(*a*) Max. dead load shear = +1·30....[Refer para (M)(1), Part V(*b*)].

(*b*) Max. negative live load shear = Max. negative live load shear in panel two because there is no live load at points L_2, L_3 and L_4 by condition (*d*) of live loadings.

= −0·7 in thousands of lb. [Refer para (M)(1), Part V(*b*)].

Thus we see that no counter-brace is required in the 4th panel.

(2) Fig. 125.

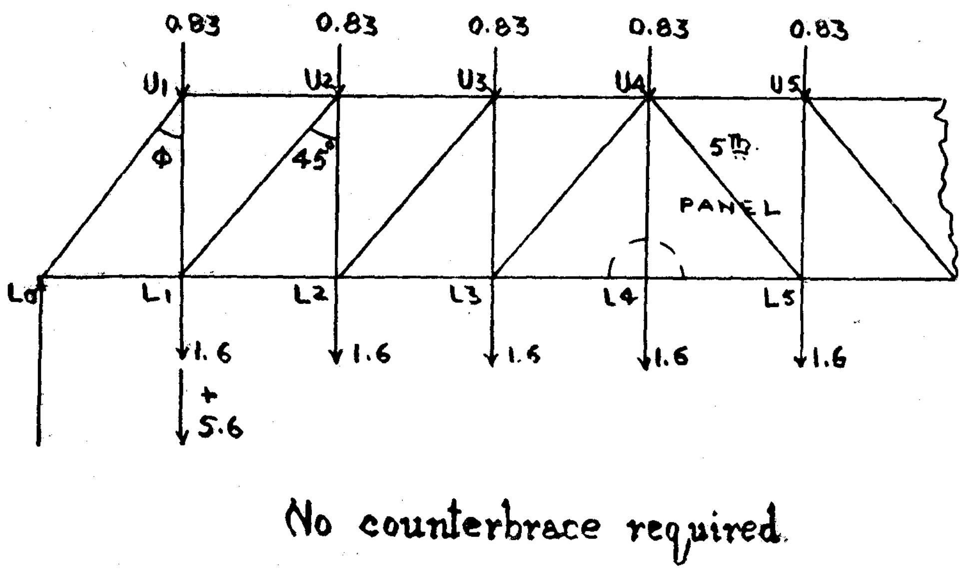


fig. 125.

Similarly considering panel 5 we could deduce that condition of counter-brace is not satisfied in 5th panel.

Thus all diagonals are under stress in all the panels as per Fig. 125.

(3) Therefore, stress in $U_4 L_4$ can be found by taking a circular section at L_4 due to dead load.

(*a*) $\therefore S_{U_4L_4}$ due to dead load = Downward forces at L_4 due to dead load = $-1 \cdot 6$ in thousands of lb.

(*b*) Max. negative live load at L_4 = Downward forces at L_4 due to panel live loads at L_4
= 0, because there is no panel live load at L_4 as per condition (*d*) of live loadings.

(4) From para (3)(*a*) and (*b*) above, we see that there is yet no reversal of stress due to condition (*d*) of live loadings.

(5) Conclusion drawn from conditions (*a*), (*b*) and (*c*) of para (U), pages 283 to 289.

Under conditions of loading mentioned in para (U)(*a*), (*b*) and (*c*) and determining max. negative live load stress we find that they are always tensile, the minimum being zero in case (*d*) (3)(*b*). It should be noted that unlike as in $U_3 L_3$ no compressive stress in $U_4 L_4$ occurs under any condition of live loadings as per table below :—

Max. negative live load stress in		Position of live loadings	Remarks for	
$U_3 L_3$	$U_4 L_4$		$U_3 L_3$	$U_4 L_4$
5·6 tensile	4·2 tensile	Points L_1, L_2 and L_3 loaded	Para (T)(*a*), Figs. 112, 113	Para (U)(*b*), Figs. 120, 121
0 stress	2·1 tensile	Points L_1 and L_2 loaded	Para (T)(*b*), Figs. 114, 115	Para (U)(*c*), Figs. 122, 123
0·7 *compressive*	0 stress	Points L_1 loaded	Para (T)(*c*), Figs. 116, 117	Para (U)(*d*), Figs. 124, 125
..	7·0 tensile	Points L_1, L_2, L_3 and L_4 loaded	..	Para (U)(*a*), Figs. 118, 119

(V) Thus minimum live load stresses (i.e., max. negative live load stresses) in vertical and diagonal members of the Howe truss under any of the different conditions

[as mentioned in paras (T) and (U)] of panel live loadings can be tabulated as follows :

Members	Max. negative live load shears in panel in thousands of lb. Refer para M(1), Part V(*b*)	Minimum live load stress in lb. arrived at from max. negative shears	Remarks
1	2	3	4
Verticals ..	..	..	Stress in a Vertical = shear in the panel
$U_4 L_4$ ..	..	0	Refer conditions discussed in para (U)(*d*) above
$U_3 L_3$ ..	..	700 lb. (Compressive)	Refer para (T)(5)(*b*)
$U_2 L_2$ ..	$-$ 0·7	700 lb. (Tensile)	
$U_1 L_1$ ..	0	0	
Diagonals ..	..	..	Stress in diagonal = shear in the panel $\times$ sec ϕ = V $\times$ sec 45° = V $\times$ 1·415
$U_4 L_3$ ..	$-$ 4·2	5940 (Compressive)	4200 $\times$ 1·415 = 5940
$U_3 L_2$ ..	$-$ 2·1	2970 (Compressive)	Refer para (L)(2), Part V(*b*)
$U_2 L_1$ ..	$-$ 0·7	905 (Compressive)	700 $\times$ 1·415 = 905
$U_1 L_0$ ..	0	0	

(W)

(1) For ease of visualisation as to what happens by way of stresses (i.e., forces) in different members of Howe truss due to

(i) Dead load on bridge, creating dead load stresses in different members.

(ii) Live load on bridge, creating

(*a*) Max. live load stress (due to max. positive shears).

(*b*) Min. live load stress (due to max. negative shears).

(2) We find :—

(*a*) Thence, Resulting Max. Stress in each member due to para (W)(1)(i) and (W)(1)(ii)(*a*), creating worst condition for safe design of members,

(*b*) and Resulting Min. Stress in each member due to para (W)(1)(i) and (W)(1)(ii)(*b*), creating temporary relief from strain in each member.

(3) Now the stresses (i.e., forces) produced by paras (W)(1) and (2) above, in each of the members are placed on an outline diagram Fig. 126,

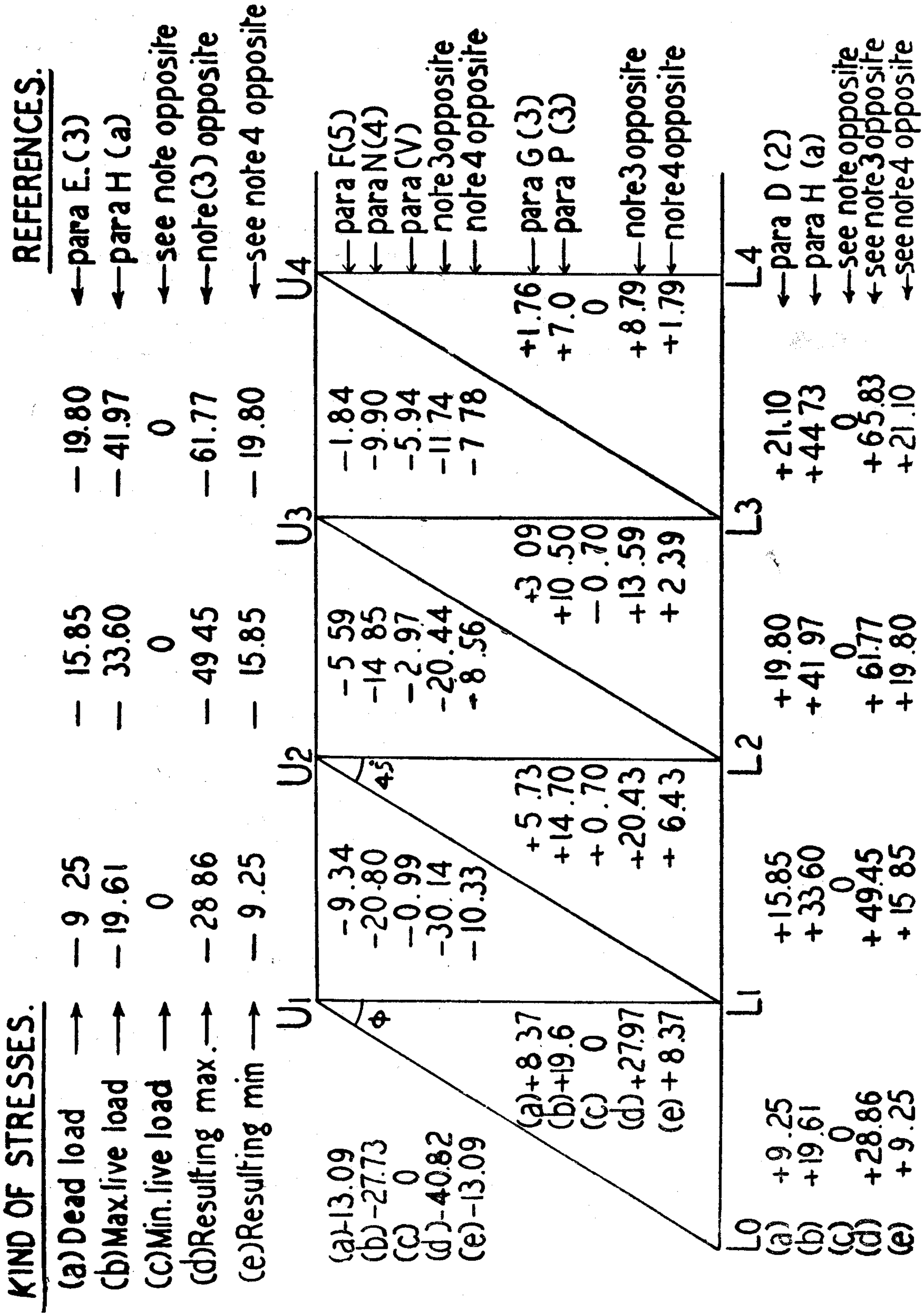

KIND OF STRESSES.
(a) Dead load →
(b) Max. live load →
(c) Min. live load →
(d) Resulting max. →
(e) Resulting min →
REFERENCES.
←para E. (3)
←para H (a)
←see note opposite
←note (3) opposite
←see note 4 opposite
U1
U2
U3
U4
L0
L1
L2
L3
L4
− 9 25
− 19.61
0
− 28 86
− 9 .25
− 15.85
− 33.60
0
− 49 45
− 15.85
− 19.80
− 41.97
0
− 61.77
− 19.80
(a)-13.09
(b)-27.73
(c) 0
(d)-40.82
(e)-13.09
(a)+8.37
(b)+19.6
(c) 0
(d)+27.97
(e)+8.37
-9.34
-20.80
-0.99
-30.14
-10.33
+5.73
+14.70
+0.70
+20.43
+6.43
-5.59
-14.85
-2.97
-20.44
-8.56
+3.09
+10.50
-0.70
+13.59
+2.39
-1.84
-9.90
-5.94
-11.74
-7.78
+1.76
+7.0
0
+8.79
+1.79
←para F(5)
←para N(4)
←para (V)
←note 3 opposite
←note 4 opposite
←para G (3)
←para P (3)
←note 3 opposite
←note 4 opposite
(a) +9.25
(b) +19.61
(c) 0
(d) +28.86
(e) +9.25
+15.85
+33.60
0
+49.45
+15.85
+19.80
+41.97
0
+61.77
+19.80
+21.10
+44.73
0
+65.83
+21.10
←para D (2)
←para H (a)
←see note opposite
←see note 3 opposite
←see note 4 opposite
45°
Φ

Fig. 126.

(X) Explanation and use of Fig. 126 in the design of members of the Howe truss :—

(1) Putting the stresses on the outline diagram of Fig. 126 greatly helps in adding up (algebraically) the stresses to give

'the max. stress for worst condition of loading' as shown by para (W) (2)(*a*) above.

(2) On these numerical figures [i.e., values of (*d*) in Fig. 126] shall be based the design of various members of the Howe truss.

[NOTE.—(To be read in conjunction with Fig. 126)

(i) No minimum live load stress is given for the top and bottom chords against kind of stress in (*c*) Fig. 126, because this is evidently zero in all cases of top and bottom chords since no position of live load will cause a reversal of stresses in these chords (as was noticed from Fig. 76, Part V(*a*), *Indian Forester*, January, 1951)].

(ii) (*a*) Max. live load stresses as mentioned against (*b*) in Fig. 126 are calculated from Max. positive shears [Refer para H(*a*), page 140, *Indian Forester*, February, 1951].

(*b*) Minimum live load stresses as mentioned against (*c*) in Fig. 126 are calculated from max. negative shear [Refer para (L) page 196, *Indian Forester*, March, 1951].

(iii) Resulting Maximum Stresses as mentioned against (*d*) in Fig. 126 are arrived at from the algebraic sum of kind of stresses under (*a*) and (*b*) in Fig. 126.

(iv) Resulting Minimum Stresses as mentioned against (*e*) in Fig. 126 are arrived at from the algebraic sum of kind of stresses under (*a*) and (*c*) in Fig. 126].

EXAMPLE.—To find the max. stress for worst condition of loading for the diagonal $L_0 U_1$ in Fig. 126.

From Fig. 126 : for member $L_0 U_1$

(i) the dead load stress = −13090 lb.

(ii) (*a*) Max. live load stress = −27730 lb.

(*b*) Min. live load stress = 0 lb. ....(i.e., zero stress).

(iii) (*a*) Resulting Max. stress = −40820 lb.

(*b*) Resulting Min. stress = −13090 lb.

(*Note.*—Negative indicates that nature of stresses are compressive).

(3) Thus the design for finding sizes of diagonals $L_0 U_1$ will be based on the worst condition of loading giving Resulting Max. stress in $L_0 U_1$ which is

= 40820 lb.

= 18 tons approx.

(4) We shall design all diagonals and counter-braces on this stress (force) of 40820 lb.

[*Note.*—Although stresses in diagonals go on decreasing from left to the centre of the truss—observe this from Fig. 126 under 'resulting

max. stress'—we shall design all diagonals on this force (i.e., 40820 lb.) only as will be explained in para (Y) below].

(5) Similarly all the vertical members will be designed on that vertical member which carries the greatest Resulting Max. stress. This occurs in vertical U_1 L_1 and is equal to 27970 lb. = 13 tons approx., see Fig. 126.

(*Note*.—Observe that Resulting Max. stresses in the verticals go on decreasing from left towards the centre of the truss, Fig. 126).

(6) Similarly the members of top and bottom booms will be designed on that chord member which carries the greatest resulting max. stress. This occurs in the centre bay L_3 L_4 and is equal to 65830 lb. = 29 tons, see Fig. 126.

(*Note*.—Observe that Resulting Max. stresses in members of top and bottom booms go on decreasing from the centre towards both the supports, see Fig. 126).

(Y) Some miscellaneous important notings :

(1) In other types of construction, e.g., reinforced concrete bridges, all-steel bridges, etc., we may design various members of the truss separately for their individual max. stresses they carry and thereby cause economy of materials and thus cause an overall economy in the complete structure.

(2) In the case of timber bridges for urban and rural areas, the same remarks and application as in para (Y)(1) above can be followed but there is a lower limit to the size of a timber member with regard to

(*a*) making effective workable joints,

(*b*) standard stock sizes,

(*c*) comparative cost of

(i) utilizing some extra volume of timber on one hand against,

(ii) sawing charges and waste on the other hand.

(3) For timber structures in Forests if all the members are separately designed then the cost of sawing timber to many varied sizes may be more than the cost of extra amount of timber involved (i.e., used) in keeping to one uniform size for all members of the same type.

e.g.

(1) Bottom boom designed on Resulting Max. stress in L_3 L_4

(2) Top boom ,, ,, ,, ,, ,, ,, U_3 U_4

(3) Verticals ,, ,, ,, ,, ,, ,, U_1 L_1

(4) Diagonals ,, ,, ,, ,, ,, ,, L_0 U_1.

(Z) We shall compare later in Part V(*c*) the results of stresses in members of Howe truss of the same type due to (*a*) Graphical method,

(*b*) Analytical method,

(*c*) Stress diag. method.

(*To be continued*)

NOTE :—Separate copies of this article can be obtained from the P.L.O., F.R.I. and Colleges, Dehra Dun on payment.

EROSION PATTERNS IN THE SIWALIKS

BY R. M. GORRIE, D.SC.
(*Soil Conservation Officer, Ceylon*)

G. S. Puri's excellent and thoughtful paper on "The Problem of Land Erosion and Landslips in the Hoshiarpur Siwaliks" in the February 1949 issue of the *Indian Forester* emphasises the contribution which the basic geology of an area makes to the local erosion pattern. Puri is correct in pointing out that the direction of dip in Hoshiarpur is consistently north to south and that the scarp face on the northern flank of each ridge is steeper than the southern dip slope. This is all the more remarkable when it is realized that the basal peneplain towards the south is considerably lower than the internal valley bottoms within the Siwaliks, and so the southern trend of gullying and ravine cutting has a deeper trough to work into. Outside the Hoshiarpur district the same topography can be recognized in the Jhelum Salt Range which is an outlying repetition of the Siwalik geology and which shows the same tendency for steeper scarp slopes to the north and somewhat gentler dip slopes to the south. The same general plan can be identified in the Dehra Dun Siwaliks and also in Simla and Rawalpindi where the lower ranges although in the Himalaya are geologically Siwalik or similar origin.

In discussing the various stages of gully formation with particular reference to the Siwalik formation I have noted ("Soil and Water Conservation in the Punjab", 1946).— "If there is any hard pan or layer it will protect the rotten rock below, but if there is none, the 'C' horizon may be even more vulnerable and collapse in vertical slumping" : and again : "The presence of any pan or induration near the surface may serve as a tray ; if this is impervious it will exaggerate the rate of sheet-wash so that all the soil on top of it is removed quickly, but if it forms a cap, to preserve everything below it"....."The third stage is when undercutting by these vertically carved gullies reaches the parent rock. If this consists of very deep layers of rotten and decomposed rock which has lost its cohesion, or if there is no real rock but merely uncompacted sand or pebble beds, as commonly occur to great depths in the Siwaliks and the underlying plains strata associated with them, chasms of very great depth will be formed quickly. This stage is usually marked by pot holes appearing in exposed channels"....."The fourth stage is when deep gullies eat backwards uphill behind them, the surface drainage forming a waterfall over the exposed ledge. Where this exposed ledge is part of an indurated crust which resists water action, further horizontal cutting may be arrested for sometime, but usually the softer strata below this ledge tend to cave in to such an extent that a portion of the indurated ledge is left unsupported and eventually breaks away in a block, then the process is repeated all over again at the new tip".

This explains why the southern dip slope is comparatively smooth while the steeper northern scarp slope is generally steeper but built in a series of gigantic steps.

The extent to which the monsoon storms in Hoshiarpur and the eastern Siwaliks beat upon the southern face rather than on the more sheltered northern one is not repeated in the Salt Range, where in fact the heaviest storms originating from non-monsoon storms come in from the north-west. Here the effect of dip and scarp appears to be a more important factor (reflected in a segregation of *Acacia modesta* on the southern and *Olea cuspidata* on the northern slopes). Against this there is the stereotyped ecological convention that all southern faces in the northern hemisphere carry a poorer plant cover due to the more damaging effect of frost on the southern exposure, irrespective of other ecological or geological factors.

One other point I should like to add to Puri's observations on the progress of denudation in Hoshiarpur. We have to accept his graphical acceleration between 1852 and 1936 as substantially correct, and the tendency is to some extent still towards acceleration. But the history of the area is sufficiently well known to allow us to break down this graph into two pictures. One is for the slopes accessible to the plains, disforested in a big way from 1840 onwards (starting with the search for fuel for brick burning for the early Sirhind Canal) and on up to 1938 (when the fashion for village volunteer afforestation first began to have an appreciable effect in reclothing the *southern* slopes).

The second picture is for the northern and less accessible areas of the Hoshiarpur Siwaliks, such as the Sohan Dun, which escaped the earlier holocaust of felling for canal supplies and remained more or less untouched until about 1900 when the pressure of population made itself felt in the pace of forest clearance around many of the more remote Siwalik villages whose cultivable land and herds increased rapidly from about 1900 onwards. This applied particularly to the two Sohan valleys, the Naraingarh tahsil and the Bilaspur State border, which up till then had remained largely under forest. It was such areas that Conservator Baden Powell had in mind when he advocated in the 1870s the reservation of the remaining forests along the Himalayan foothills and particularly in the Siwaliks. If his farsighted recommendations had been acted on sooner the district would be far better off to-day. The fact remains that deterioration in the hinterland of the Hoshiarpur Siwaliks, though much later in starting than on the outer slopes, has gone on to a much greater extent and even to-day the process of destruction, which to some extent has now been reversed on the outer slopes by afforestation and grazing closures, continues unchecked in the hinterland where effective closures are not nearly enough to counterbalance destruction of cover.

One can, therefore, add a note to Puri's graph on page 46 that half the area was deteriorating from 1840 onwards but that the full tide of destruction was not active over the whole until about 1900, since when it has continued unchecked with only minor modifications in the last 50 years due to partial afforestation and closures.

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INDIGENOUS CELLULOSIC RAW-MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART I.—PULPS FOR WRITING AND PRINTING PAPERS FROM *ARUNDO DONAX*

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INTRODUCTION

A species of grass known as *Arundo donax* grows in certain parts of India, Burma, North Asia, North Africa and Europe. In India it is generally found in the lower Himalayan region from Kashmir to Nepal at an altitude of about 3,500 feet and from the Punjab to Assam, the Uttar Pradesh Tarai, the Naga Hills, the Circars, the Nilgiri Hills and the Coorg Hills. *Arundo donax* is used in Italy for the production of pulp for viscose rayon[1 2]. Marinotti[3] has described a high alpha-cellulose pulp from *Arundo donax* from Venetia suitable for the manufacture of viscose rayon. In their investigations on the suitability of annual plants as raw-materials for the manufacture of sulphate pulps, Jayme and co-workers[4] prepared pulp with 89·3% alpha-cellulose content from Greek *Arundo donax*. According to Hornke[5] the pulp obtained from the Spanish reed, *Arundo donax*, by the nitric acid process using 1·4% nitric acid at 95–100°C for digestion and 1% caustic soda at 100–105°C for after-treatment had 94–95% alpha-cellulose content and was easily bleachable. Roosignoli[6] studied the production of pulp from *Arundo donax* by the neutral sulphite process and obtained long-fibred pulps which gave paper with high strength properties. A French patent[7] was taken in 1938 for the manufacture of cellulose of a high degree of purity suitable for making explosives and rayon from common reeds such as *Arundo donax*. Since vast quantities of *Arundo donax* are found in the U.P. Tarai, an investigation was carried out on the production of chemical pulp suitable for paper at the Forest Research Institute, Dehra Dun. Results of this investigation are recorded in this leaflet as an interim report

GROWTH CHARACTERISTICS AND USES[8]

Arundo donax belongs to the family Gramineae, tribe Arundineæ. It is known in U.P. as "Narkul" grass. It is also known as "Nal" which name it shares with another species called *Phragmites karka*. It is a tall reed-like perennial grass. It grows abundantly in moist

places along the ditches and streams but it will also grow on dryish soil when established. The stem is erect, simple or sparingly branched and varies from 4 to 18 feet in length. It arises from a stout creeping rhizome and is many noded, smooth, green and hollow with thin walls. The leaves are broad at the base, rounded or almost cordate and taper to a fine point. The leaf sheaths are tightly wrapped round the stem (stem-clasping) and ligules are membranous with dense hairs behind. The inflorescence is a large, terminal branching panicle clothed with silky hairs, nodding at the tip and light brown or yellowish brown in colour. The lemmas of the floret are long and hairy on the back in the lower half. The flowering season of this species is from August to December and the seeds are ready by January. This grass reproduces vigorously from sprouts and root suckers. In this country its yield per annum was estimated at over 3 tons per acre.

In the field it is very often confused with another species of grass called *Phragmites karka* which also grows in similar habitats. *Phragmites karka*, however, differs from *Arundo donax* in the following respects. The leaves of *Phragmites karka* taper to a long, fine point, base rounded. The leaf sheaths are not stem-clasping but rather loose. The ligule is a ciliate line. The lemmas of the florets are glabrous on the back but the rachilla (axis of the spikelet) is covered with long, white hairs which lengthen as the grain ripens giving a beautiful silvery appearance to the panicle. The inflorescence is usually brownish purple in colour.

Arundo donax is known as giant reed grass and is used for lattices, mats, screens, walls, roofing and in musical instruments. It is not a suitable pasture species. It is not very palatable to cattle but during drier seasons the animals do not hesitate to graze this species, the younger shoots being eaten first. Because of its ability to thrive on sand dunes it has been extensively used on the King Ranch (Texas) to prevent wind erosion in sandy areas. It is being increasingly recognized as a sand binding species and as a pasture grass in sandy areas. As mentioned earlier *Arundo donax* is used as a source of cellulose for the manufacture of viscose rayon in Italy.

THE RAW-MATERIAL

The reeds used for the experiments were supplied by the Divisional Forest Officer, Dehra Dun, from Motichur Range. The length of the reeds varied from 8′ to 10′. About 8–10 reeds weighed 1 lb. These were light yellowish green in colour. Leaves formed about 45 per cent of the whole, i.e., reeds with leaves. For some experiments leaves were removed from the reeds and the latter were then crushed between the rollers of the factory crusher and for others the reeds without the removal of the leaves were crushed. The crushed material was cut into chips about 1 inch in length. Fines were rejected by sieving the chipped material on the factory sieves. This chipped and sieved material was used for this investigation.

CHEMICAL ANALYSIS AND FIBRE LENGTH

In order to have an idea of the cellulose content and other constituents of the reed, the material stripped of the leaves was chemically analyzed by the standard Forest Products Laboratory methods,[9] except in the case of the estimation of pentosans where the TAPPI standard T 223m–48 was employed.

About 250 grams of the crushed chips were converted into dust by disintegration in a laboratory disintegrator and the material passing through 60 mesh and held over 80 mesh was used for the analysis. Results of the chemical analysis are given in Table I.

TABLE I

(*Chemical analysis of Arundo donax*)

	Property	% on the oven-dry basis except moisture
1.	Moisture ..	9·11
2.	Ash ..	3·58
3.	Cold water solubility ..	9·20
4.	Hot water solubility ..	11·26
5.	1% caustic soda solubility ..	34·89
6.	10% caustic potash solubility ..	44·39
7.	Ether solubility ..	0·12
8.	Alcohol-benzene solubility ..	6·79
9.	Pentosans ..	18·36
10.	Lignin ..	21·97
11.	Cellulose (Cross and Bevan) ..	58·00

From these results it is seen that the cellulose content of this reed is quite high and compares favourably with that of sabai grass (*Eulaliopsis binata*) which is one of the raw-materials of the paper industry in this country. The fibre length of this reed shorn of its leaves varied from 0·80 m.m. to 2·80 m.m., with an average of 1·45 m.m., which is less than that of sabai grass (about 2·0 m.m.) but is nearly equal to that of Esparto grass (about 1·5 m.m.) used in the British paper industry.

PRODUCTION OF PULP

A number of digestions were carried out using the sulphate and the soda processes. In the sulphate method a mixture of caustic soda (N_aOH) and sodium sulphate ($N_{a_2}S$) in the ratio of 2 : 1 by weight was used. In the soda process caustic soda alone was used. Digestions carried out by the sulphate process on uncrushed chips of the reed with 15% total alkali at 153°C for 4 hours yielded hard-cooked pulp with plenty of shives. In all subsequent digestions material was crushed between the rollers of the factory crusher and then chipped. A number of digestions were carried out to study the effect of pretreatment of the chips with dilute hydrochloric acid and water on the yield, bleach consumption and strength properties of the resultant pulps. In these experiments the chips were soaked in dilute hydrochloric acid of different strengths and also in water for about 18 hours and then the digestions were carried out by the sulphate process. The results showed that these pretreatments offered no special advantage.

In the initial experiments the leaves were removed from the reeds before digestion. Since this process of removal of leaves requires additional operational costs and also because the leaves form about 45 per cent of the reeds, digestions were carried out using reeds with leaves. Lower yields were obtained when the reeds were digested with the leaves. In order to find out whether this was due to the leaves, a digestion was carried out using leaves only. A number of digestions were carried out by the one-stage ("overhead")[10] sulphate process using different amounts of total alkali, temperatures and periods of cooking. A digestion was also carried out using the two-stage ("fractional")[10] method of digestion by the sulphate process in order to

study whether this method offers any special advantages on the "over-head" method. The results of these experiments are given in Table II.—(*See page 5*).

Since Paper Mills in this country usually employ the soda process for the digestion of sabai grass and since one of the objects of this investigation was to find the possibilities of providing additional raw-material to the Paper Mills, a number of digestions were carried out on *Arundo donax* by this process. Digestions by this process on crushed chips with 15% alkali at 153°C for 4 hours yielded hard-cooked pulps with plenty of shives. Digestions were then carried out with 16–18% alkali at higher temperatures and for longer periods. The results of these experiments are given in Table III.—(*See page 7*).

Discussion

It is seen from the results given in Table II that *Arundo donax* can be used for the production of writing and printing papers with satisfactory strength properties by a suitable choice of the conditions of digestion. The yields of unbleached and bleached pulps are satisfactory and so also is the bleach consumption. The quantity of alkali required for digestion is also satisfactory. The conditions of digestion of Serial Nos. 2–4 in Table II give good yields of pulps of satisfactory strength properties. In this connection it may be noted that Tomeo and co-workers[11] found that 12–16% total alkali was best for digesting *Arundo donax* from Zaraoza (Zurea) Province by the sulphate process. The chlorine consumption for good bleaching was found by them to be 5%. The lower yields of pulps in cases where reeds together with leaves are used are due to the presence of leaves which yield lower quantities of pulp as can be seen from the bleached pulp yield obtained when only leaves were used (*cf.* Serial No. 9, Table II). Since the leaves form about 45% of the *Arundo donax* stems and the bleached pulp yield is 30% when the whole material is used without the removal of the leaves compared to the bleached pulp yield of 36·6% when reeds without leaves are used for digestion, it is more economical to use the stems without removing the leaves for the production of chemical pulp for writing and printing papers.

Results given in Table III show that writing and printing papers of satisfactory strength properties can be prepared from pulps prepared from *Arundo donax* by the soda process. On comparing the results of the digestion conditions of the Serial No. 3, Table III with those of the Serial No. 6, Table II, it is seen that pulps in slightly higher yields are obtained by the sulphate process than the soda process.

Arundo donax is available at present in Dehra Dun at about Rs. 50 per ton whereas sabai grass (*Eulaliopsis binata*) costs over Rs. 80 per ton. Whereas 33–35% bleached pulp yield can be obtained from sabai grass, 30% bleached pulp yield is obtained from *Arundo donax* by the sulphate process when the reeds are used as such without the removal of the leaves. From the foregoing it can be said that *Arundo donax* can be used as an additional raw-material for the production of paper in this country. Pilot plant trials will be conducted to confirm these laboratory results.

Conclusions

Digestion of *Arundo donax* by the sulphate process for 6 hours using 17–18% total alkali in 4% concentration at 162°C for the first hour and 153°C for the remaining period has been found to yield easy bleaching pulp from which writing and printing papers with satisfactory strength properties can be made. The reeds must be crushed in a crusher before digestion. Soda process can also be used for the digestion of this reed but slightly lower yields of pulp are

obtained in this case than when the sulphate process is used. Considering the quantity of alkali required for the digestion, the bleach consumption, the yields and strength properties of pulps, the cost of the reed and its availability, it can be said that *Arundo donax* is a useful raw-material for the paper industry. It can be used either by itself or its pulp can be mixed with pulps of other raw-materials like sabai grass or bamboo for the production of writing and printing papers.

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TABLE II.—*Sulphate digestions of Arundo donax*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder, i.e., 35% available chlorine*	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	17	4	162° for the first hour and 153° for the remaining period	6	15·8	42·6	5·39	36·3
2	17	4	do.	6	15·8	35·0	5·33	30·0
3	18	4	do.	6	16·3	40·0	5·20	36·6
4	18	4	do.	6	16·3	34·0	5·30	30·0
5	18	4	162° for the first 3 hours and 153° for the remaining period	6	17·0	40·0	5·11	33·1
6	18	4	do.	6	17·0	38·0	4·64	29·1
7	18	4	162°	6	16·7	33·2	4·72	27·9
8	6 in the first stage and 10 in the second stage	1·5 in the first stage and 2·5 in the second stage	120° in the first stage and 153° in the second stage	2 hours in the first stage and 3 hours in the second stage	14·9	40·0	4·60	34·0
9	18	4	162° for the first hour and 153° for the remaining period	6	17·1	29·0	11·20	14·5

* The % is expressed on the basis of the raw-material (air-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear Factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metre	metres	%				
175	63·1	9348	4·8	116	57	1168	Reeds without leaves were used for the digestion. In this as well as in Serial Nos. 2–9, well cooked pulps without shives were obtained.
175	62·0	9650	4·5	113	58	1347	Reeds with leaves were used.
175	60·5	9271	4·5	112	55	1429	Reeds without leaves were used
175	59·2	9379	4·5	108	58	1279	Reeds with leaves were used.
180	63·0	8426	4·5	95	51	1165	Reeds without leaves were used.
130	64·2	9360	4·7	94	54	1139	Reeds with leaves were used.
180	61·3	8072	4·0	96	51	1060	Reeds with leaves were used.
325	61·6	6581	4·5	99	42	1216	"Fractional" method of digestion was employed using reeds without leaves.
..	..	..	..	..	..	..	Only leaves were used for the digestion. The bleached pulp had a yellowish tinge.

TABLE III.—*Soda digestions of Arundo donax*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	16	4	162° for the first hour and 153° for the remaining period	6	15·0	45·0	10·86	35·0
2	18	4	162° for the first 3 hours and 153° for the remaining period	6	15·7	45·0	6·02	38·3
3	18	4	do.	6	17·0	35·0	5·53	27·1
4	18	4	162°	6	16·5	31·6	5·42	27·6

* The % is expressed on the basis of the raw-material (air-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metre	metres	%				
170	60·6	9399	4·3	96	55	1250	Reeds without leaves were used. Hard cooked pulp with shives was obtained. The bleached pulp had a yellowish tinge.
180	62·3	9325	4·1	114	54	1407	Reeds without leaves were used. Well cooked pulp was obtained.
135	63·0	9017	4·0	90	54	1248	Reeds with leaves were used. Well cooked pulp was obtained.
180	62·6	7085	3·3	73	35	144	Reeds with leaves were used. Well cooked pulp was obtained.

FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

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PART II

(*Continued from the* "Indian Forester", *April 1951, page 246*)

CEYLON

Ceylon is an island of about 25,500 square miles in extent ; in length 270 miles from north to south and 140 miles in breadth. The forests are of varying types, the most valuable being in the wet zone which occupies the SW. part of the island and all of the foothills below the plateau up to 4,000 ft. The rainfall in this region is heavy (100″ to 200″ a year).

Although to a great extent the forests resemble those of South India which is situated so near Ceylon there are many species of trees peculiar to Ceylon and resembling more closely the Malayan trees—for instance in the Dipterocarp genera. As elsewhere in Ceylon heavy inroads have been made in these forests to open up tea gardens and plantations of coffee, tea, rubber and cinnamon and other products. In the past this was thought by the Government to be developing the Colony. Whereas the cutting of this type of forest and exposure of the soil so long protected by its forest canopy has led to erosion on an immense scale with the consequent silting and flooding of the low-lying country and the destruction of the cultivated areas.

What is termed the mountain zone situated at over 4,000 ft. above sea-level comprises the south central table land of about 4,000 square miles. The rainfall is almost equally heavy in this zone. By a regulation issued in 1874 the forests above 5,000 ft. in this zone were preserved, about 130 square miles. But much clearing of land for coffee or tea had been done ere that date in the belief that it was really developing the island and much of the largest and best tea plantations are here.

The forests here are chiefly protection forests, their importance being far greater than if they produced timber for the markets. For years past the Forestry Department has been planting exotics in this region, conifers, eucalyptus and Australian wattles. In the north-east and south-east this type gradually merges into the dry one, which covers two-thirds of the island and nine-tenths of its forest area. This more or less dry to arid forest region is of little value and has been subject to unchecked firing and shifting cultivation.

Roughly the agricultural lands amount to something over 3 million acres, the forest areas, productive and unproductive to 13 million acres with 161,000 acres of other land.

The policy of the period between 1830 or thereabouts to the end of the century in granting large areas of land in the belts of forest country, the richest productive forests, for tea and coffee gardens to which was added later rubber, cinnamon, etc., has led to terrible erosion and degrading of land values.

The Acting Conservator of Forests has kindly given me the following information on the chief main rivers of Ceylon and their chief tributaries, with lengths of each. He has pointed out that the rivers and tributaries bear more than one name as they pass through the various parts of the country.

CHIEF MAIN RIVERS OF CEYLON AND THEIR CHIEF TRIBUTARIES

1. *Mahaweli Ganga*	*length 182*	*miles*
Tributaries		
(i) Amban Ganga Kalu Ganga	,, 62·4	,,
(ii) Ulhitiya Oya	,, 40·3	,,
(iii) Heen Ganga	,, 18·1	,,
(iv) Hepola Oya	,, 22·2	,,
(v) Loggal Oya	,, 26·5	,,
(vi) Badulu Oya	,, 36·5	,,
(vii) Uma Oya	,, 44·7	,,
(viii) Hulu Ganga	,, 16·3	,,
(ix) Maha Oya	,, 11·7	,,
(x) Kotmale Oya Agra Oya	,, 27·5	,,

2. *Gal Oya*	*length 56*	*miles*
Tributaries		
(i) Ekgal Ara Sengapodi Aru	,, 21	,,
(ii) Pallang Oya	,, 17·8	,,
(iii) Namal Oya	,, 13·3	,,
(iv) Selakka Oya Kobbe Oya	,, 14·5	,,
(v) Balabadde Oya	,, 9·3	,,

3. *Kumbukkan Oya*	*length 65*	*miles*
Tributaries		
(i) Alakola Ara Katuwel Ela	,, 12·8	,,
(ii) Hulundawa Oya	,, 14·2	,,

4. *Nilwala Ganga*	*length 45*	*miles*
Tributaries		
(i) Kanduwela Ela	,, 6·8	,,

5. *Menik Ganga*	*length 66*	*miles*
Tributaries		
(i) Darage Ara Kumbukpituya Ara	,, 16·8	,,
	length 66	*miles*
(ii) Hangunne Ara Pamandiya Ara	,, 15·7	,,
(iii) Kuda Oya	,, 21·5	,,

6. *Kala Oya*	*length 87*	*miles*
Tributaries		
(i) Panikamkulam Ela	,, 9·4	,,
(ii) Lunu Oya	,, 14·2	,,

7. *Walawe Ganga*	*length 69*	*miles*
Tributaries		
(i) Man Ara	,, 22·8	,,
(ii) Rakwana Ganga Tumbulketiya Ganga	,, 19·5	,,
(iii) Kuda Oya	,, 21·7	,,
(iv) Wali Oya Kalkanna Oya	,, 17·5	,,
(v) Belihul Oya	,, 11·2	,,

8. *Gin Ganga*	*length 57*	*miles*
Tributaries		
(i) Puhulduwa Ela Galagoda Ela	,, 14·2	,,
(ii) Kiriwil Dola Maha Dola	,, 5·1	,,

9. *Kalu Ganga*	*length 75*	*miles*
Tributaries		
(i) Kuda Ganga Kukul Ganga	,, 34·1	,,
(ii) Niriella Ganga Karawita Ganga Delwala Ganga	,, 22·7	,,
(iii) Hangomuwa Ganga Hadalgama Ganga Rakwana Ganga	,, 26·4	,,
(iv) Wey Ganga	,, 25·6	,,
(v) Denawak Ganga	,, 15·7	,,

10. *Kelani Ganga*	*length*	84 *miles*
Tributaries		
(i) Maskeliya Oya	,,	19·6 ,,
(ii) Kehelgama Ganga / Hambantota Oya	,,	26·0 ,,
(iii) Pahuru Oya	,,	5·9 ,,
(iv) Getahetta Oya	,,	10·1 ,,
(v) Gurugoda Oya	,,	15·7 ,,
(vi) Sitawaka Ganga	,,	21·5 ,,
11. *Deduru Oya*	*length*	86 *miles*
Tributaries		
(i) Kimbulwana Oya	,,	25·9 ,,
(ii) Hakwetuna Oya	,,	21·2 ,,
	length	86 *miles*
(iii) Maguru Oya	,,	16·8 ,,
12. *Maha Oya*	*length*	70 *miles*
Tributaries		
(i) Kuda Oya	,,	14·2 ,,
(ii) Kegalle Oya	,,	11·9 ,,
(iii) Rambukkan Oya	,,	15·1 ,,
13. *Malwatu Oya*	*length*	102 *miles*
Tributaries		
(i) Kal Aru	,,	25·3 ,,
(ii) Narivili Aru	,,	13·1 ,,
(iii) Kanadara Oya / Weli Oya	,,	28·7 ,,

The amount of forest still standing on the upper reaches in the mountains and hills of these main rivers from their source down is about 1,091,000 acres.

The amount of forest still standing on the main tributaries of each of the main rivers is about 1,463,300 acres.

The total catchment area of all the main rivers and tributaries is about 11,546,240 acres and what still remains forest is about 2,529,300 acres.

The above information relative to the forest areas was given me in March 1950 by the Acting Conservator of Forests.

MALAYA

By concentrated recruitment, to the effective gazetted staff from the early years after the 1914–18 war, Malaya, or the Federated Malay States as it is better known, built up a fine efficient and numerically strong Forestry Department. In fact by the early 1930's the Malay Forest Department had, taking into account the disparity of areas, a stronger gazetted cadre than even India.

It will not be surprising, therefore, that far greater forestry progress had been made than in other Colonies such as Nigeria, etc., where the Forestry Staff had been maintained far below forestry efficiency requirements.

Mr. T. A. Strong, late Director of Forestry in the Restored Department after the defeat of the Japanese and the taking over of the country again, has sent me an interesting note on the country. Since Mr. Strong was a former forestry student at Edinburgh and went out to the Malay Forest Department in 1921, the information he sends is particularly valuable. His report is as follows :—

> "Taking Malaya as a whole, all the upper catchment areas, and the greater part of the lower ones are under high forest and are properly protected. In the Western States they have already all been created Forest Reserves and in the East, preliminary steps have already been taken to reserve them, progress of reservation being limited by survey and land settlement. It is expected to be completed in the course of the next few years".

Rivers of the Federation of Malaya

States are taken in anti-clockwise direction commencing with the North-Western-most State.

Notes.—

(i) SUNGEI = River.

(ii) Mileages are very approximate.

State of Kedal :—

(i) Sungei Muda, 120 miles.

Tributary, Sungei Ketil, 55 miles.

In both catchment areas the extent of ruined, abandoned land is negligible. They are covered with high forest interspersed with limited areas of secondary growth.

(ii) Sungei Kedah, 70 miles.

Catchment area similar to (i) above.

State of Perar :—

(i) Sungei Perak, 230 miles.

Upper catchment area under high forest (say 20 miles). This is followed by almost 30 miles stretch of riparian cultivation up to a depth at the most of one mile on either bank. Exposure not severe.

Tributaries—

(*a*) Sungei Piah, 45 miles. All essentially under high forest.

(*b*) Sungei Sengoh, 45 miles. All essentially under high forest.

(*c*) Sungei Kinta, 80 miles. Extreme source, possibly 5 miles under high forest, remainder of catchment area has been and still is being heavily mined of tin. Erosion and silting severe.

(*d*) Sungei Batang Padang, 85 miles. Upper catchment area has fairly dense population of Sakai (aboriginals) who practice shifting cultivation. Possibly one quarter of the total upper catchment has been or is being cultivated. As, however, secondary growth re-establishes cover in about 2–3 years, exposure is not so severe as might have been expected. Lower catchment area has some mining and is subject to moderate degree of erosion but not extensive.

(ii) Sungei Bernam, 130 miles. Whole catchment area under high forest except for negligible areas of shifting cultivation.

State of Selangor :—

(i) Sungei Selangor, 90 miles. Hill ridges and upper slopes of upper catchment area under high forest but lower slopes and valleys heavily mined in the past for tin with severe erosion and silting. Lower catchment area has mining and also fairly extensive development for rubber estates and small holdings. Mining land eroding heavily and rubber land suffering from sheet erosion. Both mining and planting technique have improved to a very marked degree and erosion has reduced substantially but the old abandoned areas are still a menace.

(ii) Sungei Langat, 110 miles. Upper catchment area mainly under high forest. Some mining with erosion and silting, but to a much lesser extent than Sungei Selangor. On the other hand, more land under rubber with relatively quick run-off.

State of Johore :—

(i) Sungei Muar, 150 miles. Upper catchment area mainly high forest, with possibly 10% under shifting cultivation and small holdings. Latter have quick run-off but limited erosion. Lower catchment, partly under fairly intensive cultivation (mainly small holdings) and partly under old abandoned cultivation : now carrying sheet *Imperata* with quick run-off.

Tributaries—

(*a*) Sungei Palong, 50 miles. Catchment area under high forest.

(*b*) Sungei Segamat, 40 miles. Catchment area under high forest.

(ii) Sungei Sinpang Kanan, 90 miles. Upper catchment under high forest. Lower catchment about 30–40% under rubber or abandoned cultivation carrying *Imperata* and scrub, quick run-off.

(iii) Sungei Johore, 90 miles. Catchment area mainly high forest, limited amount of mining, rubber planting and small holdings. Total erosion slight.

(iv) Sungei Sedili Besar, 60 miles. Catchment area almost entirely high forest.

(v) Sungei Endau, 130 miles. Catchment area principally high forest but with riparian strip of cultivation.

Tributaries—

(*a*) Sungei Sembrong, 90 miles. Upper catchment area all high forest. Lower catchment area mainly forest but with some areas of rubber and oil palm.

(*b*) Sungei Selai, 40 miles. Catchment area all high forest.

(*c*) Sungei Lenggor, 40 miles. Catchment area practically all high forest.

State of Pahang :—

(i) Sungei Rompin, 100 miles.

Tributaries—(*a*) Sungei Keratong, 80 miles.
(*b*) Sungei Jeram, 50 miles.
(*c*) Sungei Aur, 40 miles.

All of these catchment areas can be taken as being under high forest. There are small scattered patches of mining and areas of native cultivation but these are of no real significance.

(ii) Sungei Merchong, 50 miles. Catchment area mainly high forest.

(iii) Sungei Bebar, 60 miles. Catchment area mainly high forest.

(iv) Sungei Pahang. The actual river bearing this name is only about 230 miles long but the total drainage area is very extensive with a large number of tributaries. The Sungei Pahang has no catchment area proper of its own, the tributaries being its catchment.

Tributaries—

(*a*) Sungei Bera, 90 miles. Catchment area all high forest.

(*b*) Sungei Triang, 90 miles. Catchment area all high forest.

(*c*) Sungei Lipis, 60 miles. Upper catchment area high forest. Lower catchment area possibly 25% rubber and small holdings with quick run-off.

(*d*) Sungei Semantan, 90 miles. Upper catchment area has ridges under high forest ; lower slopes and valleys under fairly intensive tin mining. Older areas subject to fairly severe erosion and silting ; newer working better

controlled but run-off is rapid none-the-less. Lower catchment proportionately more forest and less mining.

(*e*) Sungei Telom, 120 miles.

(*f*) Sungei Tanum, 60 miles.

(*g*) Sungei Tahan, 50 miles.

(*h*) Sungei Tembeung, 120 miles.

(*i*) Sungei Tekai, 60 miles.

(*j*) Sungei Kechou, 60 miles.

Tributaries (*a*) to (*j*) have their catchment areas almost entirely under high forest. There are patches of tin mining and areas of shifting cultivation (which go under cover again in 2–3 years) but these form an insignificant proportion of the total.

(v) Sungei Kuantan, 80 miles. Upper catchment area under high forest. Lower catchment has restricted areas of tin mining.

State of Trengganu :—

(i) Sungei Chukai, 80 miles. Catchment area almost entirely high forest with very restricted patches of mining and native cultivation.

(ii) Sungei Dungun, 80 miles. Catchment area essentially under high forest.

(iii) Sungei Trengganu, 130 miles. Catchment area under high forest.

State of Kelantan :—

(i) Sungei Kelantan, 120 miles. This name is given to the main river only, consequently there is no catchment under this name.

There are, however, several important tributaries covering an extensive drainage area.

Tributaries—

(*a*) Sungei Lebir, 120 miles. Catchment area all high forest except for riparian belt of native cultivation which may reach a mile in width in parts and tends to accelerate the run-off.

(*b*) Sungei Galas, 100 miles. As for (*a*) Sungei Lebir.

(*c*) Sungei Nengiti, 100 miles. Catchment area essentially high forest but with fairly large Sakai settlements ; there are relatively extensive areas of secondary growth with slow to medium run-off.

(*d*) Sungei Pergau, 80 miles. As for (*c*) Sungei Nengiri.

Apart from timber and gums Malay's chief occupations and exports are tin and rubber—the latter grown from the first early beginnings of planting towards the end of last century and early years of the present.

When the true *Ficus elastica* trees in the Assam forests had been exhausted a big plantation of that species was commenced at Tezpur in Assam in the late years of last century. By then rubber had achieved a world demand.

The planting of para rubber in Malaya on an increasing scale not only resulted in the Tezpur plantation being given up but in the *Ficus elastica* product practically going off the large markets.

But apart from requirements of the local population and the exports, the demands made by the tin industry for mining poles, etc., and the rubber industry for the better types

of forest lands, the Forest Department have had a great deal of work on their hands during the last four decades which has resulted in Mr. Strong being able to give the valuable detailed information above recorded.

SARAWAK

For administrative purposes Sarawak is divided into five divisions, the first division being in the SW. and including Kuching, the capital of the country and the other divisions stretching in a north-easterly direction, the fifth division which includes Brunei being in the extreme north-east.

From the maps received, a physiographical map and a topographical map, the fresh-water swamp forest occupies a broad band on the north and west of the Colony. The high forest occupies the rest of the land surface in large blocks of varying extent. The boundaries of these, as given on the map, are approximate only.

The Conservator of Forests writes—

"The remaining area does of course contain patches of virgin forest, but in the main is made up of agricultural lands and includes vast areas of secondary forest, the direct result of shifting cultivation. Animal husbandry as such does not exist so that there is no damage caused by excessive grazing. The following approximate figures may be of interest :—

	sq. m.
Primary or very old secondary forest	27,826
Mangrove and associated forest	466
Freshwater swamp forest	5,770
Tree crops (Plantation rubber, coconuts and sago)	652
Wet rice cultivation (actual and potential) ..	1,903
Hill land under shifting cultivation (rice) ..	8,933
Hill land derelict from shifting cultivation ..	1,521
Total area of the Colony ..	47,071

"The chief rivers are :—

(*a*) The Rejang river in the third division (a division is an administrative block) which has a very large drainage area. It is navigable for ocean going vessels for 160 miles as far as the small village of Kapit. Large vessels up to 10,000 tons, can and do, enter and load at the top of the broad estuary above Rejang. Above Kapit the Rejang divides two main branches, the Balui and the Baleh. Main tributaries below this point are Kanowit, Poi and Ngemah.

(*b*) The Baram river in the fourth division although a large river has a very bad bar some four miles long and only small coastal vessels can enter. In fact all other rivers, except the Sarawak river in the first division and on which the capital town Kuching is situated, have bad bars navigable only to small coastal craft but once inside there is a good depth of water.

(*c*) Proceeding up the coast from the mouth of the Sarawak river, other rivers of note are :—The Simunjan or Sadong, Batang Lupar, Saribas, Oya, Mukah, Balingian Tatau, Bintulu or Kemena, Suai, Niah, Sibuti, Limbang, Trusan and Lawas.

"The Sarawak river is navigable for ocean going steamers up to 1,500 tons for 23 miles up to Kuching town.

"Just on 10% of the forest area of the Colony is now reserved forest, but all of this is by no means productive. The target under the development plan is a minimum of 25% of which 10% is to be productive and the balance protective".

The disquieting feature of the report is the presence of the bars at the mouths of so many of the rivers—even as large a river as the Baram with a bar some 4 miles long and now only navigable to small vessels. The bar is, of course, the result of silt brought down from the hills and agricultural lands due to erosion from devastated areas. This has repeated the known history of the east and west coasts of Southern India (Madras and Bombay) when by 1850 lists were drawn up of small coastal ports which had become choked with silt and had bars formed near the mouths of the rivers due to the excessive exploitation of the forests and the practice of unchecked shifting cultivation. (See India p. 225).

BRITISH BORNEO

Some useful information on the subject of forest and catchment areas comes from North Borneo, sent by Mr. H. G. Keith, Conservator of Forests. It may be hoped that any leases given out to timber companies, such as, The Borneo Company Ltd., etc., may bear conditions on overcutting and that the Forest Department shall retain in its authority the necessary supervision over areas so leased.

On the subject of water supplies and catchment areas Mr. Keith gives the following information—"I attach an estimate covering about 67% of the area of the Colony. The omission of the smaller rivers accounts for the balance". This estimate is given in the following table :—

River	Length miles	Chief Tributaries	Length miles	Area drained sq. miles	Amount of forest (percentage of area drained)
1		2			3 & 5
Kinabatangan & Penungah ..	180	..	..	3,825	50
		Lokan	50	830	90
		Kuamut	60	840	80
Segama ..	135	..	..	2,035	70
		Bole	25	165	80
Kalumpang ..	50	..	..	635	95
Morutai ..	25	..	..	210	80
Brantian ..	25	..	..	210	90
Kalabakang ..	40	..	..	480	60
Serudong ..	55	..	..	400	80
Padas ..	130	..	..	2,615	20
		Pengalan	60		
		& Sook	30	1,780	10
Papar ..	30	..	..	350	20
Tuaran ..	25	..	..	560	2
Tempassuk ..	25	..	..	350	0
Bengkoka ..	40	..	..	400	20
Paitan ..	25	..	..	295	70
Sugut ..	85	..	..	1,340	80
Labuk ..	95	..	..	1,820	50
		TOTAL ..		19,140	

"You will appreciate that the enclosed estimate does not claim to be accurate but it is the best we can do at present".

INDONESIA

(Formerly the Netherlands East Indies)

The Report of the Commission set up in London under the auspices of the Royal African Society in 1942 to study deforestation and erosion in Africa and other tropical countries. During the session of the Commission, Mr. A. Muhlenfeld, Head of the Department for West Indian Affairs, Netherlands Ministry for the Colonies gave the members of the Commission an excellent eye picture of the questions in Java and the outer Provinces. Since his remarks are the latest we have they are reproduced here :—

Note on Deforestation in the Netherlands East Indies.

"As regards the question of forestry, there is a very great difference between the island of Java, including Madœrs, and the outer Provinces. On the one hand we have Java, the most densely populated country in the world (nearly 50,000,000 inhabitants over an area of 132,000 sq. kilometres, that is to say, nearly 400 inhabitants per square km.) and, on the other hand, the outer Provinces, nearly 14 times as large, with a population of only 23–24 millions, about half that of Java and not more than 20 inhabitants per square km., i.e., one-twentieth of the density of the population of Java. It is obvious that, under these conditions, the population of Java had to take up a far greater proportion of land for its agriculture than the population of the other islands, except in some places such as Bali, where the density of population is also very great. When we consider that the population of Java has increased since 1815 from 4·5 millions to 48,000,000 inhabitants, i.e., an increase of 1000%, we can easily understand that such an increase could not take place without a corresponding increase in the intensity of exploitation of the soil. All kinds of measures were applied to obtain higher yields, such as the construction of enormous irrigation works, seed selection, instruction in agriculture, etc. There are, however, limits to the possibilities of establishing *sawahs*, or irrigated rice-fields.

"In increasing numbers those people who were not able to share in the scheme of communal rice-fields, nor to get individual possession of a good piece of land, went in search of new ground on the mountain sides or in distant regions still covered with forest. In the first of these cases, erosion of the hill-sides seriously affected the volume of the springs and rivers and, the second case, in which shifting cultivation was too often practised, all the results of deforestation ensued which have been mentioned in the first pages of the report of the first session of our Commission. The lack of sufficient land made it more and more difficult to feed livestock and thus the same difficulties arose in Java as have been described on page 5 of the proceedings of the second Session of our Commission. It was very soon realized that it would be necessary to take measures to safeguard the forest interests of the country and to avoid destruction which would certainly prove disastrous in the long run.

"During the time of the India Company, the population were required to deliver large quantities of timber without any precautions being taken against wasteful felling and it is certain that a large portion of Java's forest wealth disappeared during this period. Shortly after the liquidation of the Company, at the beginning of the 19th century, Marshall Daendels, the then Governor-General, took the first steps towards an organized policy and an Inspector-General of Forests was appointed. During the British domination of 1811–16, which was beneficial to the country from many points of view, Governor Raffles, who nevertheless had many admirable qualities, abolished this beneficial measure and deforestation began once more.

"During the fifty years immediately following, no consistent forest policy was followed, but matters improved after 1865. In that year regulations relating to the administration and exploitation of the forests were drawn up. They were subsequently renewed several times and improved provisions added. The original system of giving over a great portion of the *djati* (teak) forests to exploitation by private individuals or joint-stock companies was gradually abandoned once it became plain that it was not in the ultimate public interest. Thus all the responsibility for attending to the exploitation and regeneration of the forests was relegated to the Department of Forestry, although there still exist certain private interests concerned solely with the sale of timber from certain forests.

"The Forestry Department is very efficiently organized ; it includes a Chief Inspector, 11 sub-inspectors, 125 administrative staff (forestry graduates), all of whom have received a university education at the Agricultural College at Wageningen, 150 non-graduate foresters, and several thousands of assistant foresters and forest guards. The forests are classified, according to their nature, into :—(*a*) teak forests and (*b*) other forests. According to the use which it is intended to make of them, they are divided into reserved forests and forests destined to be cut down. Climatological, hydrological and orological factors determine which of the forests belonging to category (*b*) ought to be reserved. Forests around springs and those bordering rivers and streams are subject to special regulations.

"There are, moreover, penalties for all kinds of offences injurious to the forests, while very severe measures have been taken against the danger of destruction by fire. In addition, as far back as 1874, an ordinance was passed for controlling the use of new land by the natives. One of the principal clauses of this ordinance is that all permission to take possession of new land in hilly or mountainous country is made conditional on the occupier constructing terraces to avoid erosion. Forest-clearing around springs is forbidden. Similar regulations are in force for agricultural concessions.

"Shifting cultivation (under which heading regular crop-rotation should not be included) is no longer tolerated except in a few very isolated parts of the Bantam Residency, where it still exists in a very limited form. During the period from 1920 to 1940, the total area of teak forest in Java increased, from 7,390 to 8,253 sq. km., that is to say, from 5·62%–6·22% of the total area of the country. At present the total forest area is now about 23·5% of the whole area of Java.

"Reafforestation during these latter years has risen to 225 sq. km. annually. The work is carried on according to a systematic plan and many hill-sides in particular have been reafforested. In many cases we have had to come to some arrangement with the population, and sometimes whole villagers have had to be evacuated, with compensation and grants of new land. The abolition of Government coffee cultivation also made several thousands of square kilometres of land available for forest reserves. Artificial reafforestation of the slopes of a large number of mountains would entail such enormous expense that it was not be to thought of. Another method was followed therefore ; the meticulous protection, during several consecutive years, of vast areas of bush against every kind of destructive act, more especially fire and grazing. These very vigorous measures resulted in the reduction of the area of forest destroyed by fire, which in 1925 was still 7% of the total, to only one-half per cent several years later. We may say that we are on the right road and that over the greater part of the island an end has been put to destructive methods which used to cause deforestation of a menacing character.

"In the outer Provinces (Sumatra, Borneo, Celebes, Bali, Timor and New Guinea and hundreds of others), measures against deforestation only began to be taken much later and it was not until 1910 that the Forest Department set about organizing the protection of the forests. The total percentage of surface occupied by forests is much greater than in Java (1,208,000 sq. km. against a total area of 1,772,000 sq. km. or 68%). The percentage, however, varies greatly in the individual islands. New Guinea for example, has more than 80%, Borneo 77%, Sumatra 62%, Celebes 56%. The percentage in the islands of the Little Strait (Bali, Timor) is 20%. The Forest Organization comprised about 30 graduate foresters, whose first task was to collect data about the situation, area and character of the forests, as well as about the possibilities of transport of valuable timbers. Thus, by 1930, a fair amount was already known about a forest area covering 300,000 sq. km. and estimated to contain 3,000 different species, some of which were very valuable, such as the Muna teak and the various kinds of Ironwood in Borneo and Sumatra. In some of the islands shifting cultivation is still very prevalent and enormous tracts of virgin forest have, as a result, given way to bush, or to grazing grounds, if not to absolutely arid land.

"The enormous area covered by the outer Provinces (in which the extremes of distance are as far as from the West coast of Ireland to the Caspian Sea) makes it impossible to set up a Forest Department there as efficient as that of Java, but they have been going the right way to work for twenty-five years. Even more than in Java it is essential to win the co-operation of the native communities whose rights over the forests are in many cases so firmly established that nothing could be undertaken without their co-operation. As a rule, this co-operation is obtained to a point of carrying out the basic principles of the forest regulations, although, considering the limited staff available, control is not always easy in isolated parts of the islands. We have also succeeded in obtaining the cession of a large area of forests, the reservation of which was considered to be indispensible in the public interest, while a portion of the other forests, although remaining the property of the native communities, has been confided to the administration of the Forest Department, under coditions acceptable to the native communities. The same sort of difficulties existed with regard to the forests lying within the native principalities, of which there are 274 in the outer Provinces, occupying a large part of the total area of those islands. These difficulties were not insurmountable, however, as the political contracts of the Princes obliged them to govern their territories according to the principles laid down by the Government. The organization of forest administration was still only in its infancy in the outer Provinces when war broke out, and it is to be feared that under the present circumstances a great part of our work will be undone or wrecked, but there is no doubt that it will be resumed as soon as the brutal aggression of the Japanese has been ended".

In a subsequent note to the Commission Mr. Muhlenfeld wrote :—

"It appears to me to be to the point to complete my note of last February 24 with the following annotation which, I think, will help to give a clearer notion of the measures taken in the Netherlands East Indies with regard to reafforestation.

"A Government Decree of 13 May 1931, set up a Reafforestation Commission, the work of which is to advise the Government on the subject of creating better conditions for forestry in Java.

"A year later, local Reafforestation Commissions were set up in the Regencies (about 75), and on them were represented the Inland Administration, Department,

the Forestry Department, the Irrigation Department, the Department of Hydraulic Works and Electricity, the Department of Agronomic Information, Public Health, and, eventually, a representative of the War Office.

"All questions concerning the utilization of new land, land-clearing, new agricultural concessions, fresh irrigation works, reservation of land for reafforestation, etc., are dealt with in these Commissions, and in this way, there are very souled guarantees against the ill-considered use of land, which might have harmful consequences as regards erosion".

In a paper read at the World Forestry Congress held at Helsinki in July 1949, Mr. R. Sewandono, Inspector of Forests, Batavia (Indonesia) gave confirmation as to the density of population, etc., in Java. He continued—

"À Java il n'est pratiquement plus question de forêt vierge dans la plaine et dans les basses régions montagneuses. Ce sont des considérations économiques qui ont fait transformer les forêts primaires en forêts de productions pour pourvoir en la demande toujours croissante de bois de construction et d'industrie, écorces tannentes, de résines, de térébenthine et d'autres produits forestiers. La mise en culture se fait exclusivement après la coupe rase. Les soins des cultures et leur protection contre, les maladies, parasites et incendies sont très pousses. Les récoltes ont lieu selon les principes de permanence ; elles se font aussi économiquement que possible pour éviter le gaspillage de bois. Le transport se fait principalement par moyens modernes. Parmi ces forêts de productions *Tectona grandis* prennent une place importante pour la production de bois de charpente, *Agathis damara* pour le bois à la fabrication du papier, du contreplaqué et de caisses, *Acacia decurrens* pour les ecorces tannantes et *Pinus merkusii* pour le bois pour fabrication du papier, les resines et pour la térébenthine.

"Dans la haute montagne javanaise se trouvent tout de même encore des forêts qu'on pourrait appeler, avec quelque bonne volonté, forêts vierges. À cause des dangers d'érosion et les intérêts hydrologiques de la plaine, la coupe rase ne peut pas être admis ici : L'exploitation est effectuée d'une sélection rationnelle (jardinage). Mr. Kramer s'est rendu tres méritoire par ses recherches au sujet de ces bois. Il a été démontré qu'un coupage comme indiqué ci dessus garanti le rajeunissement naturel de ces forêts. Lors de ces coupures on doit éviter de faire des ouvertures de plus de 0·1 ha. Les ouvertures de 0·1–0·3 ha le plus souvent ne pourrant pas être rajeunis sans la mise en terre de plantes de semis et la lutte contre l'ivraie.

"En Indonésie, hors de Java, dans le domaine de la sylviculture on n'a pu atteindre des résultats importants. Le bois localement n'y a pas encore beaucoup de valeur. Le transport vers les centres de consommation est souvent tres onéreux. L'exploitation se borne généralement a l'abattement de troncs d'arbes de valeur. On laisse les autres dans l'espoir que la nature généreuse s'occupera de la restauration. Dans differents cas p.e. á Banka á Billiton et dans la region de marécages tourbeux il est apparu, que cette restauration se fausait vraiment rapidement. Il y a cependant de grandes chances que la composition des forêts se modifie dans un sens indésirable. Par ci par la on essaye d'ameliorer cette situation en coupant les espéces indésirables et en eclaircissant les forêts. Avec ces moyens simples on a souvent beaucoup de succès. On trouve d'autres exemples d'exploitation soignée dans les forêts de marée ou l'on ne coupe pas les arbres au desous d'un certain diamètre, ni certains seminifères. Enfin on cultivation de jeunes plantes germées sur la place (*Eusideroxylon zwagerii*)".

The above scarcely requires comment on my part.

Some of the large rivers of Indonesia are as follows :—

JAVA .. Solo, 335 miles.
Brantas, 195 miles.
Tjiliwong, 50 miles.

BORNEO .. Barito, 550 miles.
Kutei or Mahakam, 400 miles.
Kapuas, 450 miles.

SUMATRA .. Jambi or Hari, 450 miles.
Musi, 325 miles.
Rokan Keri, 225 miles.
Indragiri, 225 miles.
Kampsar Kanan, 200 miles.

FRENCH INDO-CHINA

Owing to the past Great War changes in the political environment in French Indo-China, that country, I believe, is now split up into three more or less self-governed entities under the continued supervision of France. In any event political boundaries do not alter existing forest stands, at the time the boundary or frontier changes are made.

The French had had for long a Forest Service in Indo-China which was well known by repute to foresters with East and Far East experience. Nearly all the forests were under the ownership of the State and were controlled by the Government administrations of the various protectorates and Colonies as shown in the following table prepared before the last war :—

Distribution of Forests (about 1930)

Protectorate or Colony	Total Land Area	Population	Forested Area		Forested Area per capita
			Acres	Percentage of land Area	
					(acres)
Tongking ..	29,440,000	6,000,000	8,645,000	29·4	1·4
Annam ..	33,280,000	6,124,000	14,820,000	44·5	2·4
Cambodia ..	41,600,000	1,500,000	9,880,000	23·8	6·6
Laos ..	67,200,000	550,000	23,469,000 (estimated)	34·9	42·7
Cochin-China ..	14,080,000	3,000,000	5,186,000	36·8	1·7
	185,600,000	17,174,000	62,000,000	33·4	3·6

The Forest Administration followed the Indian practice of enumerating some of the forests as Reserved which were under a more highly regulated management, the rest being classed as unreserved with fewer restrictions as to cutting. The total area of the reserved forests was 3,388,000 acres, Cambodia having the largest area 1,192,153 acres and Cochin-China coming next with 833,924 acres.

In Tongking it is said that the forests have lost their original character, as the natives have been devastating them for centuries. Primeval forests are found only at high elevations 2,300 to 4,900 ft. The forests in the valleys and plains are badly devastated and consist of inferior, undesirable species. Even the second growth has disappeared over vast areas giving place to bush or grassy savannahs. The network of streams in Tongking has suffered from the deforestation. Beds of rivers are clogged with sand banks and rocks. The action of torrents is to be seen on the mountain sides and also in the cultivated valleys. Gravel, rocks, and rushing water destroy the rice plantations in the upper valleys.

The Forests of Cambodia contain species of value which can be substituted for the timbers of France, Sweden, Russia and America. Shifting cultivation and its resultant fires is common in the province and has so far not been radically checked either in French or British colonies. As also the fires lit by the graziers for pasturage purposes.

In Annam nearly half the country is covered with forests representing the position of Burma although in Annam exploitable teak cannot be obtained from this half in spite of the fact that the forest as forest covers more than half the country. These forests represent great wealth being a combination of those of Tongking to the north, Cochin-China to south and Laos to west.

The great troubles here are waste only a portion of the great trees felled being used. Fires take place, in addition to those coming from the shifting cultivation clearings.

Cochin-China furnishes as good an example of the past still continuing in the present day as found in other parts of the world ; of forests wantonly and ignorantly wasted. The forests of Cochin-China are said to have been devastated for thirty centuries. At the time of the French occupation, and even now, enormous areas of the cleared or bush (savannah) land exists. Among the rice cultivated areas small blocks of forest and large clumps of trees exist. These are being rapidly cut out by the agricultural population just as was done in India in rice cultivation areas. We now, know that for protective reasons, these blocks and clumps should be safeguarded as being invaluable in the agricultural regions. Some countries are now, at great cost and labour and difficulties to the Forest Officer, engaged in recreating these protective blocks and clumps for shelter purposes.

The forests in the high zone appear to have suffered from centuries of destructive practices. The following is a report on the mangrove forests of Cochin-China.

> "Although the forests of the west, like those of the east, have unfortunately been intensively exploited and even destroyed from time immemorial, it is certain that deforestation in the west has taken on disturbing proportions, especially in the last few years, owing to the growing demand for fuel wood. Originally the banks of the rivers were covered, far into the interior, with a curtain of mangroves which were protected by law from being cut less than 500 feet from the banks. These laws were abrogated and the mangroves were cut. Filling of the river beds with sand, constant shifting of sandbanks and changes in the course of streams may all be attributed to the disappearance of the mangroves. These conditions make navigation difficult, and continual dredging at great expense is necessary".

Although considerable areas of the major forests have been exhausted there remain tracts which could be saved under correct management. With the present unrest and more or less dismemberment of French Indo-China the future of the forest areas does not appear in too favourable light.

SIAM

In the early years of last century imports of teak from Siam competed with those of Burma from Rangoon and thus the teak from this region was known both in India in the south when the British were extending their rule and also in Western Europe to some small extent. In the early half of that century a controversy existed as to whether the teak from Siam was of better quality than that from the Malabar forests near the west coast of Madras ; or the teak from Rangoon and later from Moulmein in the Tenasserim Province. I do not know that this controversy was ever settled. But in both of these other countries teak was practically the only timber which the markets would take and this lasted well into the present century, thus tending to the preservation of the non-teak bearing forests which amount to some 22% of the area of the country or 35 million acres of forest.

Whether the teak forests of Siam have been reduced in area or not the accessible merchantable forests cover about 4 million acres only. The teak forests are situated in the north of the country on the area extending from the northern boundary between Siam and Tenasserim comprising 3,840,000 acres. There is another strip along the Burmese frontier on the west joining the larger forests on the south comprising about 230,400 acres. This is the limit of the teak region there being no teak to the east of the Mekong river. To the south of Siam the forests are chiefly tropical mixed ones with many good species, some of which are now becoming marketable.

It is difficult to know what the present political upheavals have done but until comparatively recently the ruler of the country owned all timber and mineral rights over all the country and about 90% of the land as well. In the privately owned land timber rights and fellings were reserved to the Crown.

Thus in the past in working the teak the old method of concessions was in force which had to be obtained from the Crown. While this was detrimental to the teak forests it is difficult to say how much erosion has taken place and whether the practice of shifting cultivation has had a serious effect on the forests. But certainly up to the first of the Great Wars no management of the forests existed and there was no control of exploitation. A Forest Department was brought into being after that War but the Second World War must have brought to an end for the time being its activities.

CHINA AND TIBET

(Including Manchuria, Mongolia and Sinkiang Eastern Turkistan)

The total area of China in which Tibet is not included is roughly some 3,820,000 square miles. China proper and Mongolia having very similar populations numerically. The forest area is estimated at about 7% of the total land area. Conifers and hardwoods occur in the forests of north and central China though in the latter some of the greater warmth-demanding species of both occur. In the southern provinces tropical forests occur in the south-west of Yunnan both hardwoods and conifers. The total area of the country is 1,532,800 square miles.

Mongolia has a total area of country of 1,367,953 square miles and there are considerable areas of coniferous forest but small for the size of the country.

In Sinkiang there are considerable areas of good coniferous forest on middle slopes of high mountain ranges but forest areas are small in proportion to total area.

In Manchuria (area = 363,700 sq. miles) the forests north of the Sungari river are fir, larch, aspen, elm, oak, birch, pine and spruce in south. South of the Sungari river is oak, ash, walnut, poplar, spruce, fir, pine, larch.

Manchuria contains the chief district of extensive primeval forest in China. It reaches from the Yalu river north-east to the Ussuri with scarcely a break, and from there north-east to the Argun, extending over a thousand miles and containing vast stores of timber. This magnificent resource is an invaluable asset to China, and its conservation is of the greatest importance. The species include spruce, silver fir, red pine and larch and oak is also present in large quantities, but the most valuable timber is Manchurian pine (*Pinus mandshurica*). The eastern mountains contain the heaviest forests and the best timber, pines over 200 feet high and 5 feet in diameter are not uncommon. Although the best forests are still remote from means of transportation and have been but little exploited, the choice timber has been entirely removed from the hills along the Chinese Eastern Railway. In addition to heavy saw timber, these forests supplied Russia and China with much wood for railway ties, and the entire fuel supply of the Chinese Eastern Railway comes from them.

Regarding the forests of Eastern Turkistan and Mongolia, little is known, except that they are small in proportion to the total areas of the provinces and very difficult of access.

China proper's forests lie in three main regions—(1) the Nan-Shan or Nanling Range ; (2) the central region, chiefly in the Tsingling-Shan and Chiutiao-Shan ; and (3) the western highland region. There are also a few outlying forest areas toward the north boundary.

(1) The Nan-Shan is a very rough high mountain mass extending from the western plateau nearly parallel to the south coast along the north boundaries of Kwangsi and Kwangtung and the west edge of Fukien to central Chekiang. Much of it is inhabited by wild tribes who have never been conquered by the Chinese, hence much virgin timber is left. This timber is hard to get at, and the forest cover should be kept intact in order to protect the head-waters of the many rivers rising in the range. A good deal of timber and firewood is now being cut. In Hupeh, fir and pine are grown as crops over large areas on very short rotation. The vegetation on the south side of the range is more or less sub-tropical in character ; at the highest elevation conifers predominate.

(2) The central region consists of mountains in Shensi, Honan, Szechwan and Hupeh provinces, also spurs from the great western highlands. Considerable quantities of timber are still being cut from these mountains, but much of the remaining forest is rather difficult of access, and here, as in the Nan-Shan, *watershed protection should be paramount,* since on her rivers *depends to a large degree China's commerce* and to some extent her agriculture and her enormous fish industry. The district contains good virgin forest, mostly conifers. There is much bamboo, especially in the Nan valley.

(3) The great western plateau of Szechwan and Yunnan is partly inhabited by semi-independent savage tribes and is mostly inaccessible. With railroad development it may be able to supply some lumber to the rest of the country. In the south-west, in the valleys of the Mekong, Salween and Irawaddy rivers, the forest is tropical jungle, merging farther north into temperate hardwoods and at high elevations into coniferous forests which extend into southern Tibet. There are isolated forests in inaccessible places in Shansi, Shensi and Chihli.

In general, such forest as remains has been preserved because it could not be reached, either because of the savage tribes of the mountains or because there were no drivable streams

on which to float the timber out. There has been no attempt at control of the national forest resources until within very recent years.

Before the invasion of China by the Japanese and the Civil War, China, having created a Chinese Forest Service in 1916, had started on a study of the forestry situation and problem. From pronouncements made at different times it was the aim of the Forest Service to reforest waste lands *and the principal watersheds.* The latter gives evidence of the recognition of the serious erosion taking place in parts of the country and the increasing dangerous situation arising from this position of affairs.

Although the forests of China have been heavily over cut in the course of several thousand years, it is believed that a great part of those remaining are difficult of access and still comparatively unexploited, and it is believed that the forest area is now practically stationary. If this is true, the annual growth is probably about equal to the cut. This does not mean, however, that China's forest area is adequate for her needs. The growth balances the cut only because the cut is so small, and if the forests were nearer to the centres of consumption they would have been cut out long ago, and would not now be able to supply even the low requirements of China.

On the subject of the questionnaire addressed to the National Forestry Research Bureau, Ministry of Agriculture and Forestry, Nanking, China, the Director, Mr. H. K. Fu, has kindly sent me the following information on the subject of "Water Supplies and Catchment Areas of our country as they apply to the Forests".

> "I regret that it is informed in a very rough way, and some tributaries whose forest conditions is not known or of little importance, are omitted here".

> 1. The name of the chief rivers in China and the length in miles from the source to mouth, where they flow into the sea.

Name	Length (in miles)	Where they flow into the sea
Hei-Lung Kiang	2,790	Flowing into the sea along the Usuri river.
Sun-Wah Kiang	..	Flowing into the sea along Hei-Lung Kiang and Usuri river.
Ya-Lu Kiang	..	Antung.
Tu-Men Kiang	446	Possiet Bay.
Hwang-Ho (Yellow river) ..	2,773	Mouth of Hwang-Ho.
Yang-Tze Kiang	3,256	Woo-Sung.
Ming Kiang	297	Foo-Chow.
Si-Kiang	1,233	Kwang-Chow.
Lan-Chang Kiang	2,708	Flowing into the sea along Mekong river of French Indo-China.
Lu-Kiang	1,695	Flowing into the sea along Salween river of Burma.
Ya-Lu-Chang-Pu Kiang ..	1,173	Flowing into the sea along Brahmaputra river of India.

(The order of the rivers is from north to south).

2. The names of the chief tributaries of these rivers and the length of each of the tributaries from source to where they join the main rivers.

Name of Main River	Name of Tributary	Length (miles)	Where they join the Main River
Hwang-Ho ..	Tou-Ho ..	..	Near Lan-Chow.
Yang-Tze-Kiang ..	Gin-Tsar Kiang ..	..	Tzee-Ko.
	Ya-Lun Kiang ..	..	Zen-Ho-Je.
	Ta-Tou-Ho ..	..	Chia-Ting.
	Ching-I-Kiang ..	..	Chia-Ting.
	Min-Kiang ..	..	I-Ping.
	Siang Kiang ..	..	Tung-Ting Lake.

(Those tributaries whose forest condition is not known or of little importance are omitted here).

3. The amount of forest still standing on the upper reaches in the mountains and hills of the main rivers from their source down.

Name of Main River		Forest Area (in sq. miles)
Sun-Wah Kiang ..	..	208,880
Ya-Lu Kiang ..	..	6,126
Tu-Men Kiang ..	..	5,636
Hwang-Ho ..	..	1,544
Yang-Tze Kiang ..	..	147*
Ming Kiang ..	..	28,823
Lan-Chang Kiang, Lu-Kiang	..	3,501
Ya-Lu-Chang-Pu Kiang	..	..

* Most of the forest areas on the upper part of Yang-Tze Kiang are detailed in the answer below.

4. The amount of forest still standing on the main tributaries of each of the main rivers.

Name of Main River	Name of Tributary		Forest Area (in sq. miles)
Hwang-Ho ..	.. Tou-Ho ..	..	1,645
Yang-Tze Kiang ..	.. Gin-Tsar Kiang ..	..	6,361
	Ya-Lun Kiang ..	..	7,681
	Da-Tou Ho ..	..	359
	Ching-I Kiang ..	..	28,823
	Min Kiang ..	..	1,390
	Siang Kiang ..	..	3,501

TIBET

Tibet is a wholly mountainous region with an area of 463,320 square miles. There are good forests in the south-west, mostly conifers, with at least 4,000,000 acres adjacent to Szechwan and Yunnan.

JAPAN

It has for long been known that Japan had not only extensive forests in the mountainous regions but was one of the possibly few countries in the world (China might have been another) whose people engaged in planting and in some form of forest conservation many centuries ago.

It was not, however, till after 1864 that what may be termed modern forest management was commenced. The chief starting point came in 1907 when an administrative authority was created to prevent the destruction of forests and to secure the planting of trees in both public and private forests as well as on waste land, exemption from taxation being granted where desirable.

The clearing of forest land for cultivation could be restricted or prohibited under the law enacted. As important, to study the *relations between forests and water supplies* meteorological stations were to be erected and observations made. Special subsidies were granted for the restoration of waste public forest lands which had been denuded of forest in the past and not replanted. It was also enacted that the quantity of timber which might be felled annually to satisfy home and foreign demand for timber was to be limited so that the future supply of this commodity might not be endangered.

The first War restricted some of these wise proposals—but between 1918 and 1930 round about 320,000 acres were being planted. I should think that at this time Japan was one of the most advanced countries in forestry practice outside Western Europe, India being one of the others.

The ownership of the forests, amounting in area to some 46,000,000 acres was divided between the Crown (7%) State (39%) Communal (15%) Temples (0·6%) and Private (38%). As has been shown the Japanese had early realized the value, indeed necessity, of forming protection forest and following European Western practice private owners had under the law to maintain protection forests on areas (steep slopes and so forth) where the absence of forest would entail injury to cultivation and other property at lower elevations.

The second Great War may have altered some of the figures but before its outbreak there were approximately 3½ million acres of protection forests. Of this the Crown owned 27,450 acres, the State 1¾ million acres, Communes 1,102,000 acres and Temples 22,300 acres and Private owners 608,000 acres.

The old divisions of Japan upon which these notes are based were Japan proper, Korea, Formosa and Japanese Saghalien, the total land areas of which were respectively 97,293,427 ; 54,910,225 ; 9,036,625 ; and 8,553,600 ; total 169,793,877 acres. The forest areas were respectively 46,602,185 ; 29,375,395 ; 7,156,780 ; and 7,350,275. Total 90,484,635 acres.

The large area of the forests is due to the land formation of Japan which has large mountainous tracts covered with forests and unfit for cultivation. In this latter connection, however, the Japanese were amongst the first to terrace their hill-sides when they put them under cultivation and so reduced the certain erosion which follows cultivating steepish hill-sides by ploughing up and down hill or even round the contours without any protection against wash out.

I feel sure that had it not been for the late war and its aftermath I should have received fuller and more recent details on the progress made in Japan on the aspect of forestry discussed in this monograph. Unfortunately no such reply was received and I acknowledge that outside the data I possessed myself much of the above is taken from Zon and Sparhawk's "Forest Resources of the World" published in 1927.

It may be added that Japan possesses some fine timbers ; both conifers and hardwoods in her forests. She has long been known for her matches, her factories having outgrown possible home production and yield necessitating imports of poplars, etc., from other countries. Her important pulp factories and their increase were the result of the first great war when she had to provide for herself in view of the restricted or cessation of the Scandanavian imports.

(*To be continued*)

WEATHERING TRIALS ON AIRCRAFT WINGS

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PART III

(*Continued from* The Indian Forester, *May 1951, page 312*)

The highest differences between the maximum and minimum were as follows :—

TABLE VII

Location	Veneer	Spruce	Grids
Air	26·17	12·59	14·2
Anson	18·65	15·24	14·79
Master	16·87	..	15·48
Oxford	15·28	13·32	12·12
Mosquito	19·14	15·90	18·56

On the whole the least changes seem to take place in the Oxford and the largest in the Mosquito followed by the Anson and then the Master. In the air the greatest change was noticed with the veneers and with the other two types of specimens the changes were less than that obtained in the wings.

If we consider the number of weeks the spruce specimens and grids were above a certain moisture content the following values (Table VIII) are obtained :

TABLE VIII

Number of weeks when moisture content of grids and spruce was below 10%, 10–15% and above 15%

DEHRA DUN (1945–46)

Plane	Location	Number of weeks when moisture content was					
		Below 10%		10%–15%		Above 15%	
		Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8
Anson Mainplane Port	1	..	23	..	10	..	..
	2	17	..	29	..	1	..
	3	16	15	30	13	1	21
	11	16	17	27	13	4	19

(*contd.*)

TABLE VIII—(*concld.*)

Plane	Location	Number of weeks when moisture content was					
		Below 10%		10%–15%		Above 15%	
		Grids	Spruce	Grids	Spruce	Grids	Spruce
1	2	3	4	5	6	7	8
Oxford Mainplane Starboard	Root	35	40	14	9	..	..
	Tip	18	..	31	..	..	..
	Leading Edge	34	..	15	..	..	..
Oxford Mainplane Port	Root	44	41	5	8	..	..
	Tip	28	..	21	..	..	..
	Leading Edge	27	..	22	..	..	..
Horsa Tailplane	East Wing Centre	45	..	4	..	1	..
	Fin	43	..	5	..	..	..
	West Wing Centre	40	..	8	..	..	..
	West Wing Tip	35	..	14	..	..	..
Mosquito Mainplane Starboard	Bulkhead Centre	..	20	..	29	..	..
	Root Centre	..	25	..	23	..	1
	Leading Edge Root	..	19	..	23	..	7
	Leading Edge Middle	..	26	..	20	..	3
Mosquito Mainplane Port	Bulkhead Centre	25	..	23	..	..	..
	Bulkhead Trailing Edge	34	..	12	..	1	..
	Root Centre	30	..	18	..	..	..
	Leading Edge Centre	30	..	16	..	2	..
	Leading Edge Middle	17	..	25	..	6	..
Master Mainplane Port	..	28	..	20	..	..	..
Master Mainplane Starboard	..	28	..	18	..	2	..
	Air	7	5	27	28	14	15

As can be seen from the above the Anson seems to be affected most and the Oxford least.

Veneers were also placed in the Oxford starboard mainplane at the root near the top surface, at mid-height and bottom in order to assess the humidity conditions prevailing at these

levels inside the wing. Contrary to belief the veneers at mid-height were found to have on the whole a higher moisture content than those at the bottom or top. There were also occasions when the veneers at the top had the highest moisture content. The top veneers also seem to be more subject to the fluctuations of moisture than the others.

The values obtained during the period are given in Figs. 80–83. Table IX below gives the data regarding the maximum and minimum values attained by these veneers.

TABLE IX

Position of veneer	MOISTURE				
	% Max.	Date	Min.	Date	Difference
Top	14·83	26–9–45	0·00	9–6–45	14·83
Mid-height	15·19	,,	0·10	5–6–45	15·09
Bottom	13·30	,,	0·33	9–6–45	12·97

The difference is maximum at mid-height, closely followed by the top and least at the bottom. Lowest values as is to be expected were obtained at the top followed by mid-height and then bottom.

As earlier remarked wet and dry thermocouples were also employed in a few locations to follow the humidity changes inside the wings. These results are represented in Fig. 84. For the period under observation the lowest humidity recorded was about 12% and the highest 87% at Oxford port root. In the Anson 8% was the lowest value recorded, the highest being 85%. In the air the lowest value was 20% and the highest 98%. It is likely that lower or higher values might have prevailed at some other time or location. From the humidity prevalent the corresponding moisture content of the veneers from the E.M.C. curve (based on the data of the Forest Products Laboratory, Madison), was taken and compared with those actually found with the veneers. The ratio moisture expected/found is plotted in Fig. 85. As will be seen from Table X below the values vary from 0·38 to 27·78.

TABLE X

Wing	Lowest ratio		Highest ratio		Average ratio			
					12–6–45 to 18–6–45		19–6–45 to 31–7–45	
	Mango	Z.R.	Mango	Z.R.	Mango	Z.R.	Mango	Z.R.
Oxford	0·38	0·74	24·67	6·07	6·51	3·88	1·24	1·62
Anson	..	0·91	..	27·78	..	2·27	..	2·12
Air	0·65	0·69	3·71	3·83	2·37	2·46	1·11	1·24

As can be seen the greatest differences are in summer and later they are less. Naturally differences are to be expected as the humidity recorded is that prevailing at the moment of observation and the veneers will require considerable time to attain equilibrium during which

period the humidity will vary. This also indicates widest variations in the Anson followed by Oxford and air.

The results of moisture content variations, etc., at Cochin are recorded in Table VI and Figs. 63-65.

The above data confirm observations made in Australia that these conditions are worse in Anson wings than in the Mosquito.

Apart from their usefulness in designing specification tests the above data are also of interest from the strength point of view. It is well known that the strength properties of wood are affected by moisture content. It will, therefore, be seen that this reduction will persist for a longer period with certain locations of the Anson and the Mosquito. The Oxford will be least affected.

Recent experiments carried out both in Germany and Australia have shown that temperatures can also affect strength properties. Aircraft are likely to operate between $-40°C$ and $70°C$. Strength properties are decreased by as much as 1% for every degree rise of temperature above 20°C. Only in the case of toughness the effect is not so pronounced. Plywood strength is also affected. Modulus of elasticity and tension are affected, only at 45° to the grain. But above 12% moisture content and temperatures over 60°C there is a reduction in the strength properties both parallel and perpendicular to the grain. With adhesives it was found that with casein glue a considerable increase in strength takes place on raising the temperature from 20°C to 50°C. In the case of P.F. and U.F. glues there is a decrease in strength with rise of temperature but the temperature coefficient is very small. Work on the influence of psychrometric conditions on the strength of Indian woods, etc., is in progress in this laboratory.

From the data presented earlier it is seen that many parts of the wing including the spar may be above 70°C and above 60°C for long periods. This indicates that the strength reduction can be considerable. In the monsoon months, i.e., July and August, with aircraft parked in the open we can have both high moisture contents and high temperatures which means the aircraft will be under very adverse conditions. This has to be considered in designing aircraft for tropical service. Investigation of moisture proofing treatments and surface finishes to give as low a temperature as possible are indicated. The internal painting of wooden aircraft is worth serious consideration.

Condition of the maiplanes and materials at the end of the tests.—The mainplanes were also periodically examined as also at the end of the test. At the end representative samples of plywood, etc., were tested for their strength. Several spar laminations were also tested for glue adhesion. These results are briefly described below :—

Deterioration of the components started quite early, a few weeks after exposure. On 4th July 1945 when the first inspection was made and at subsequent inspections the following defects were noticed.

Master Port.—Severe cracking of the landing light cellulose acetate, probably caused by inadequate clearance between the rivets and the corresponding holes in the "Perspex" (Fig. 86). Slight wrinkling of the surface was also noticed. Top surface along spar was discoloured. Dope began to crack. This continued till 17-9-1945 when the top surface wrinkling had increased and the tip end had cracked letting in water. At later inspections the defects were increasing till the final inspection (Fig. 87).

Master Starboard.—Slight parting of the lower skin at the root and slight wrinkling of surface was noticed. General condition satisfactory. Drainage holes provided were adequate. Cracking of the dope had commenced. The condition of the mainplane was the same till 17–9–1945 when surface wrinkling had increased and this continued gradually till the end (*vide* Fig. 88).

Anson.—By 6–8–1945 cracking of the dope had started. Mould growth was also evident. The landing light cellulose acetate was pulling off, shrunk and badly distorted (Fig. 89). The trailing edge plywood was getting loose in many places. Bottom skin was badly wrinkled more than in other wings, cracks had started in top skin from centre towards the leading edge. This continued and the mainplane leaked at many places during later inspections. The drainage holes were not adequate and veneers got wet. Bacterial decomposition of casein glue was noticed. At the October inspection the condition of the wing had worsened. Fruiting bodies of *Schizophyllum commune* were noticed on the trailing edge facing north. More dew was noticed on this mainplane than in others. Glue joint failures were also noticed as in the trailing edge. These defects continued to increase at further inspections. (Figs. 90 and 91).

Oxford Port.—At the first inspection slight wrinkling of the top surface was noticed. Slight parting of compreg laminations at the root edges was also noticed which, however, did not progress further (Fig. 92). Landing light cellulose acetate started cracking and crazing (Fig. 93). The tank cover was badly wrinkled and the coating had cracked and flaked off in many places (Fig. 94). Discolouration in the plywood skin was noticed above spar. Casein glue was decomposing. These defects increased with time (Fig. 95). Fungus attack was noticed in the plywood (Fig. 96). The fungus was identified as a *Poria* spp.

Oxford Starboard.—Was similar to the other wing excepting that the tip end lower skin was coming off in many places. (Fig. 97).

Mosquito Port.—In July surface checking of the plywood on the top at the root end was noticed. By 17–9–45 this had further developed and leaking in the trailing edge was noticed. But the condition of this mainplane was better than others. In October fungi were noticed in many places especially the leading edge. Cracks were more at the double skin than in the single skin. In November parting of spar laminations was noticed.

Mosquito Starboard.—This was similar to the other mainplane but fungi were less. Spar web separation was noticed. (Figs. 98, 99, 100, 101).

Horsa Tailplane.—This was casein glued. In the July inspection fin post glue line had opened up to 8 inches, glue line failure was also noticed in other places. Mould growth was noticed. At later inspections defects were aggravated, there was fungus and general deterioration. (Fig. 102).

Figs. 103 to 107 illustrate the condition of the wings at Cochin at the end of the tests.

The above indicates that casein glue should be avoided and better painting and finishing systems adopted. Internal painting is also worth consideration.

STRENGTH TESTS

At the end of the weathering trials the mainplanes were broken down and the plywood, etc., tested. Some of these results are given in Tables XI and XII.

TABLE XI

Strength data on Plywood from Mainplanes at the end of weathering

Mainplane	Direction of sample	Position	y dynes/sq. cm. $\times 10^9$		Tensile strength lb./sq. in.	
			Max.	Min.	Max.	Min.
1	2	3	4	5	6	7
Oxford Port	Parallel	Bottom	204	..	11837	..
	Parallel	Top	..	10·25	..	1000 (leading edge)
	Perpendicular	Top	86·57	..	..	..
	Do.	Tank Bulkhead top	..	..	6800	..
	Do.	Top	..	9	..	1349
	45°	..	27	18	4200	2900
Mosquito Starboard	Parallel	Bottom	231	..	..	..
	Do.	Do.	..	..	9347	..
	Do.	Top (TE)	..	34·5	..	..
	Do.	Bottom	..	54·0	..	..
	Perpendicular	..	50·3	..	..	..
	Do.	..	..	..	9936	..
	Do.	..	..	9·89	..	2440
	45°	Bottom	44·67	13·02	5640	1670
Master Starboard	Parallel	Bottom	145	..	8864	..
	Do.	Top	..	22·50	..	1470
	Perpendicular	Top	16·6	..	9394	..
	Do.	Bottom	15·89	..	..	..
	Do.	Top	..	8·28	..	2598
Master Port	Parallel	Bottom	187	..	13090	..
	Do.	Top	..	59·51	..	4146
	Perpendicular	Bottom	21·88	..	9206	..
	Do.	Top	..	5·27	..	2560
Anson	Parallel	Bottom	189·4	..	8130	..
	Do.	L.E.	..	20·05	..	1760
	Perpendicular	Top	18·0	..	8421	..
	Do.	L.E.	..	6·0	..	1275

(*contd.*)

TALE XI—(*concld.*)

Mainplane	Direction of sample	Position	y dynes/sq. cm. $\times 10^9$		Tensile strength lb./sq. in	
			Max.	Min.	Max.	Min.
1	2	3	4	5	6	7
Mosquito Port	Parallel	Top	136·3	..	7657	..
	Do.	Top	..	39·4	..	1270
•	Perpendicular	Top	17·27	..	6663	..
	Do.	Top	..	9·4	..	2446
	45°	Top	25·33	11·3	2982	1185
Oxford Starboard	Parallel	Tip	192	..	14090	..
	Do.	Top	..	20·08	..	2156
	Perpendicular	..	37·8	..	12450	..
	Do.	Bottom	..	9·1	..	2130

TABLE XII

Plywood Glue Adhesion tests (Mainplanes after weathering)

Wing	Maximum				Minimum			
	Dry		Hot wet		Dry		Hot wet	
	Failing load lb./sq. in.	% Glue failure	Failing load lb./sq. in.	% Glue failure	Failing load lb./sq. in.	% Glue failure	Failing load lb./sq. in.	% Glue failure
1. Mosquito Starboard ..	516(B)	50	..	..	20(T)	0	..	..
2. Master Starboard ..	545(B)	0	396(T)	0	175(T)	0	39(T)	0
3. Master Port ..	396(T)	0	408(B)	0	204(T)	0	153(T)	0
4. Anson ..	290(T)	0	180(B)	0	22(T)	0	18(T)	0
5. Mosquito Port ..	226(T)	20	..	..	73·7(T)	0	..	..

TE. = Tip end. T. = Top. B. = Bottom.

Plywood.—Considerable variation in the strength of the plywood was noticed. Generally higher values were noticed at the bottom skin. The highest ultimate strength values (tensile) did not coincide with the highest modulus of elasticity (in bending) values. While a few values satisfy specification requirements many are far below these requirements. Least difference between the maximum and minimum values is noticed for 45° plywood. Higher values are found in the Oxford and Master bottom (13070 lb./sq. in. and 11830 lb./sq. in.) and lower values in Oxford top (1000 lb./sq. in.) and Master starboard top (1470 lb./sq. in).

If panel shear values are considered some panels gave over 2000 lb./sq. in. at the end of 4 years exposure while others gave poor values.

Glue adhesion.—The glue adhesion (plywood) tests indicate that the phenol-formaldehyde glue has stood up well. Failing loads far above specification requirements were obtained.

If the spars are considered, the Oxford spars gave satisfactory glue adhesion values (over 1000 lb./sq. in.). The Anson spars as can be seen from Fig. 91 had completely delaminated. This was glued with U.F. glue. Examination of other failed spars from Anson showed crazing (Fig. 108). It appears that the glue used was unsuitable.

Spruce.—Some of the spruce laminations used in the Anson spar on testing gave the following strength figures :—

	Spruce from spar	Specification requirements
Tensile strength ..	10,128 lb./sq. in.	..
Compression parallel ..	5,820 ,,	5,000
Modulus of rupture ..	15,719 ,,	8,000

Compreg.—The compreg at the root of Oxford when tested gave the following figures :—

Tensile strength	14,687 lb./sq. in.
Modulus of rupture	25,400 ,,
Compression	7,458 ,,

It should be remembered that these mainplanes were parked under the most adverse conditions, without any servicing which is never likely to happen in practice. The results indicate that for tropics only thermosetting phenolic resins should be used. With these adhesives and great care in the choice, selection and handling of timber and use of suitable preservative and moisture retardent coatings and care in manufacture, use and storage, wooden aircraft can be expected to give satisfactory service.

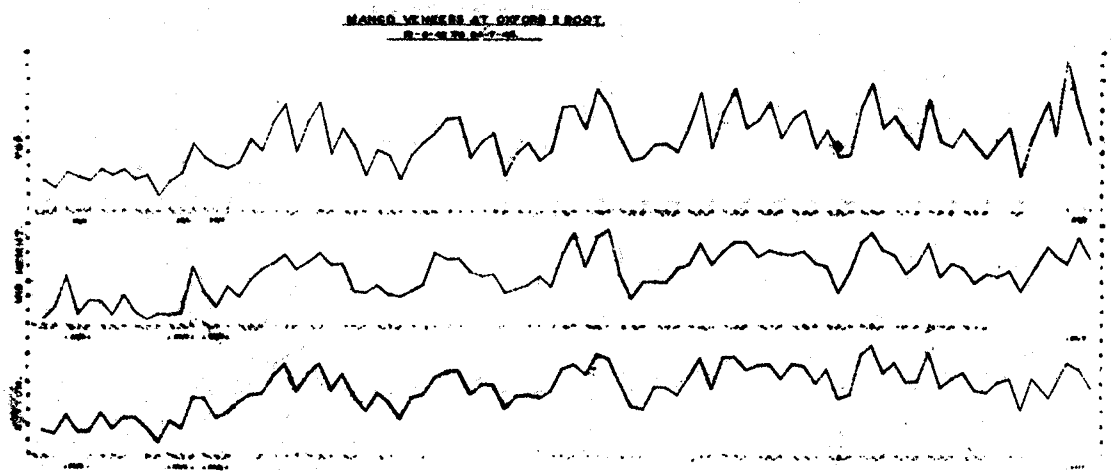

FIG. 80.—Variation of moisture content of mango veneers at Oxford port Root as affected by their position from top to bottom 19-6-1945 to 24-7-1945. See also Fig. 53.

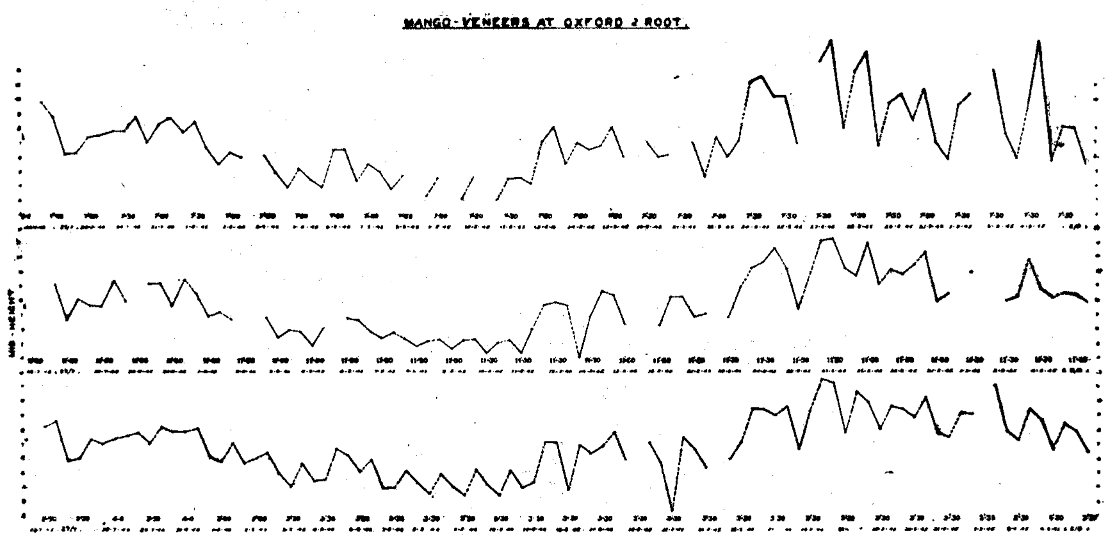

FIG. 81.—Variation of moisture content of mango veneers at Oxford port Root as affected by their position from top to bottom 26-7-1945 to 5-9-1945.

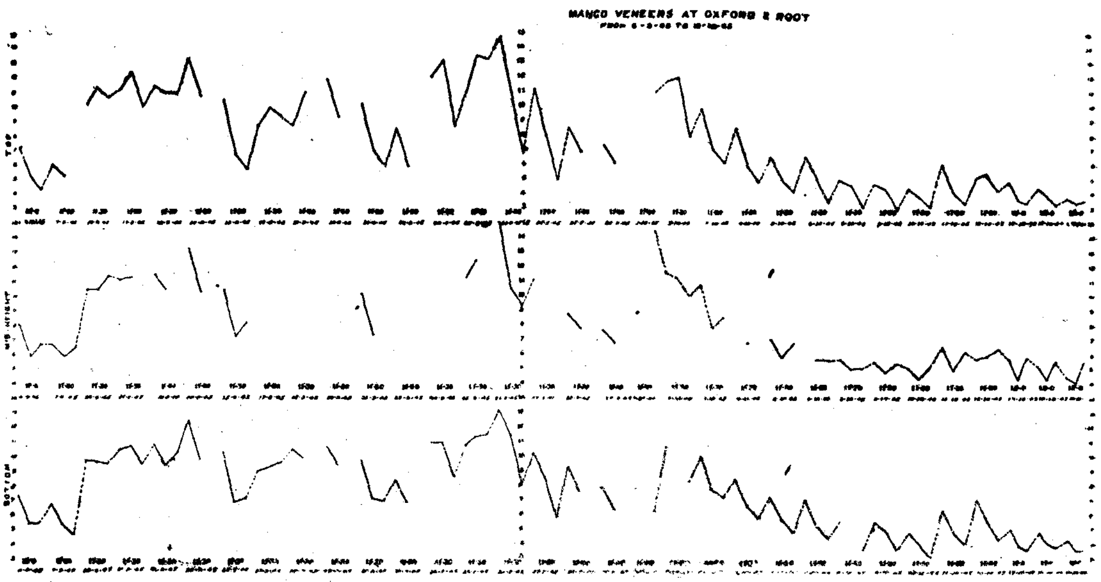

FIG. 82.—Variation of moisture content of mango veneers at Oxford port Root as affected by their position from top to bottom 6-9-1945 to 19-10-1945.

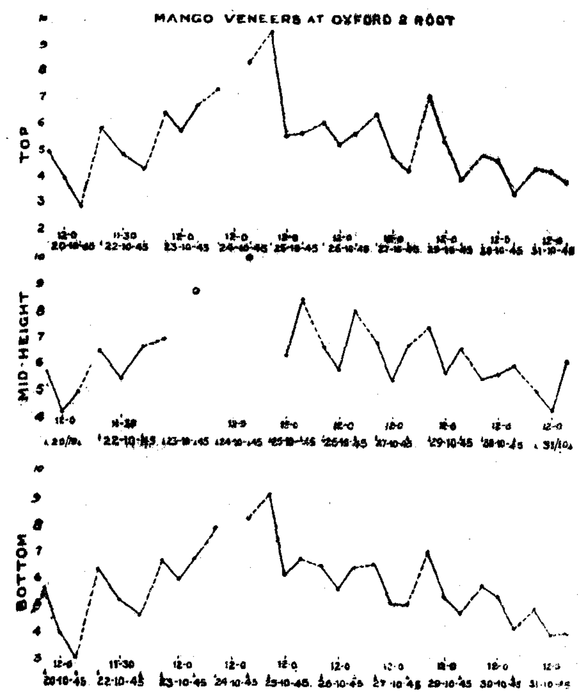

FIG. 83.—Variation of moisture content of mango veneers at Oxford port Root as affected by their position from top to bottom 20-10-1945 to 31-10-1945.

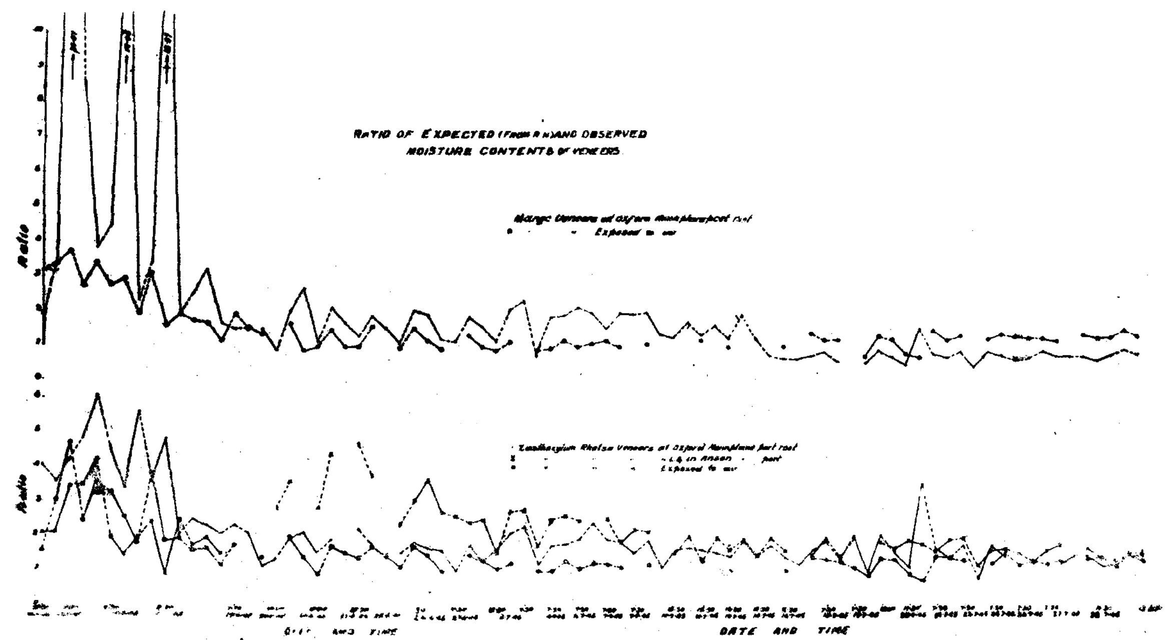

FIG. 84.—Variation of Relative Humidity in Oxford and Anson Mainplanes and in air.

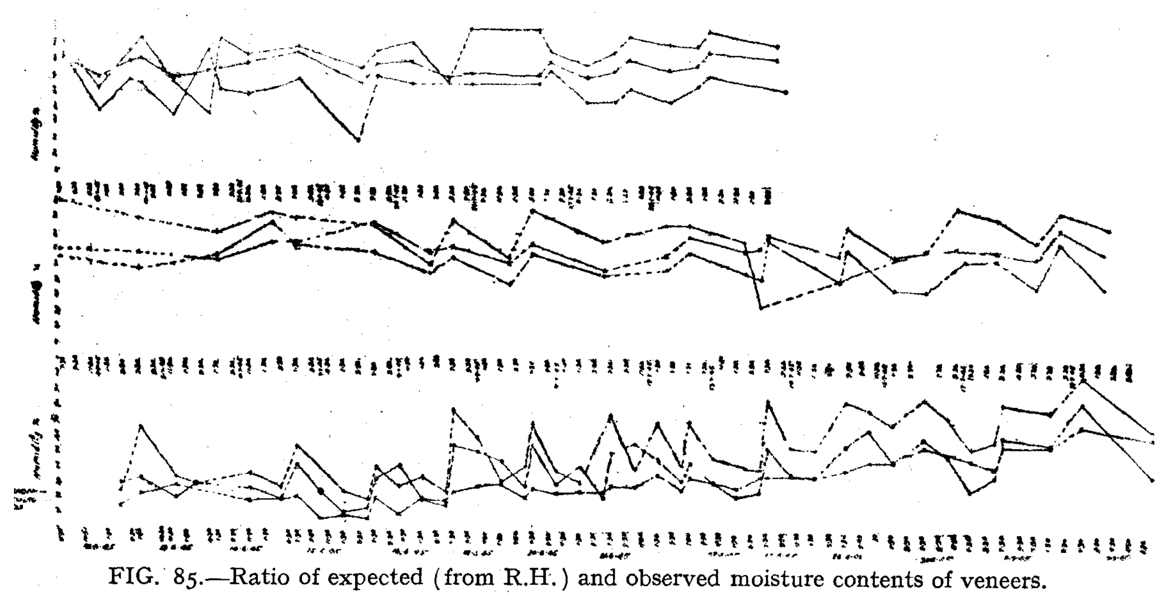

FIG. 85.—Ratio of expected (from R.H.) and observed moisture contents of veneers.

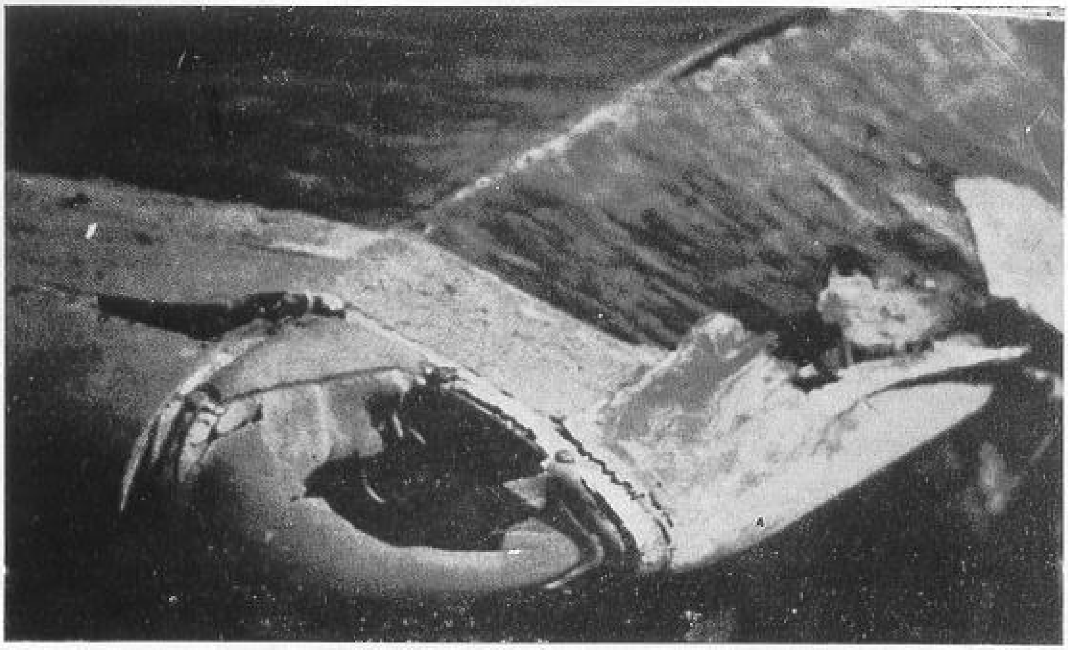

FIG. 86.—Master mainplane tip at the end of four years' weathering showing cracks in plywood and "Perspex".

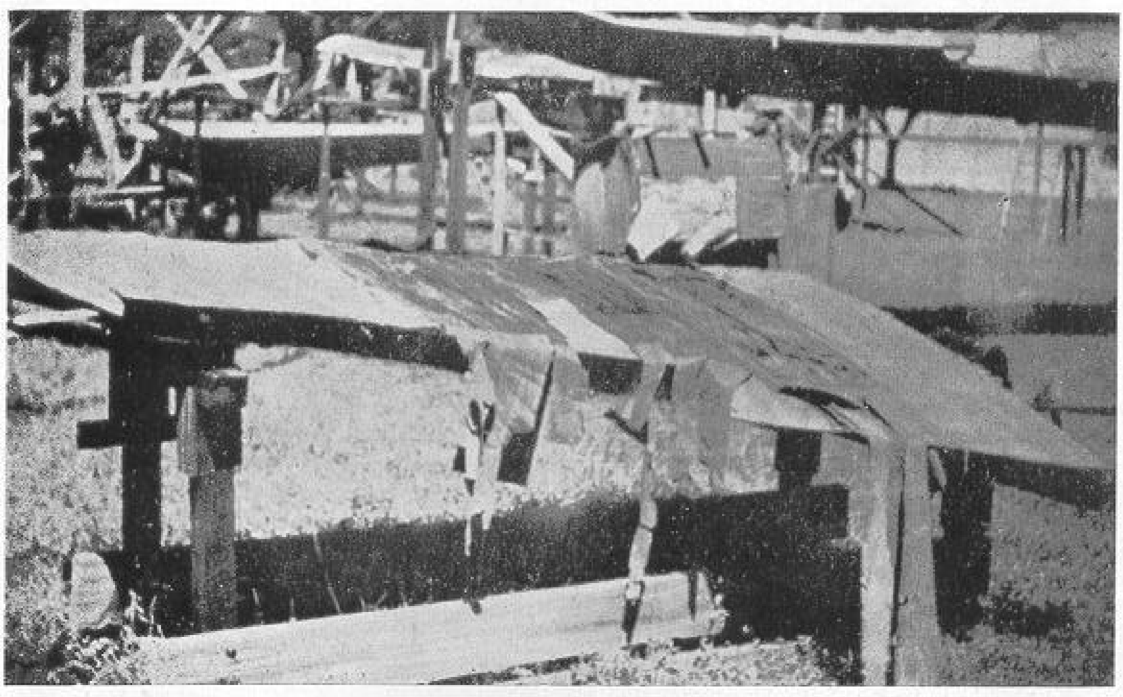

FIG. 87.—Master mainplane port after four years' weathering.

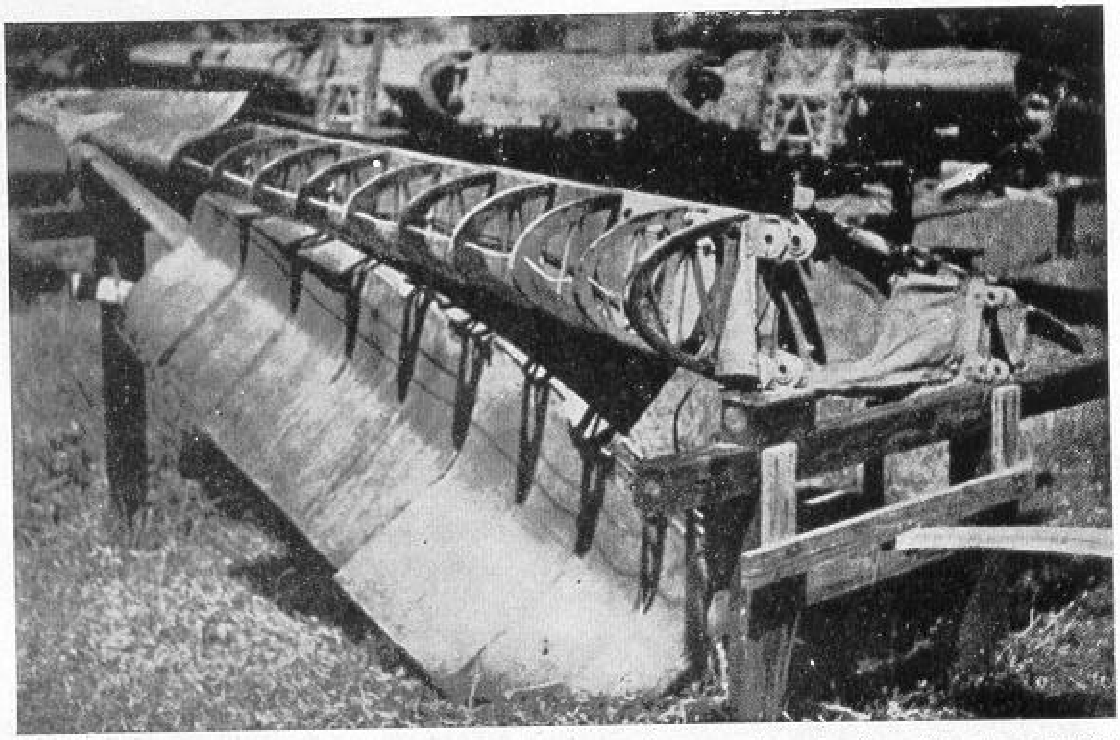

FIG. 88.—Master mainplane starboard at the end of four years' weathering. The plywood skin peeled off easily.

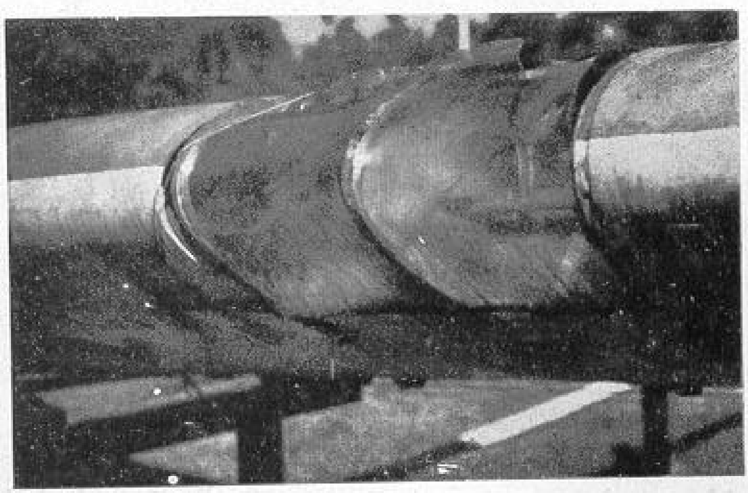

FIG. 89.—Distortion of landing light cellulose acetate in Anson mainplane.

FIG. 90.—Anson mainplane port at the end of four years' weathering.

FIG. 91.—Glue failure in Anson spar.

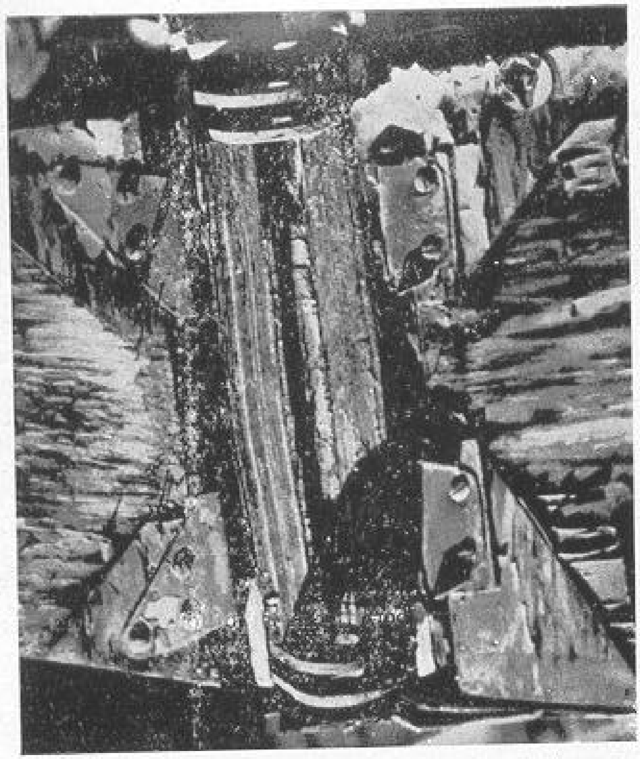

FIG. 92.—Satisfactory condition of compreg at the root end of Oxford port at the end of test.

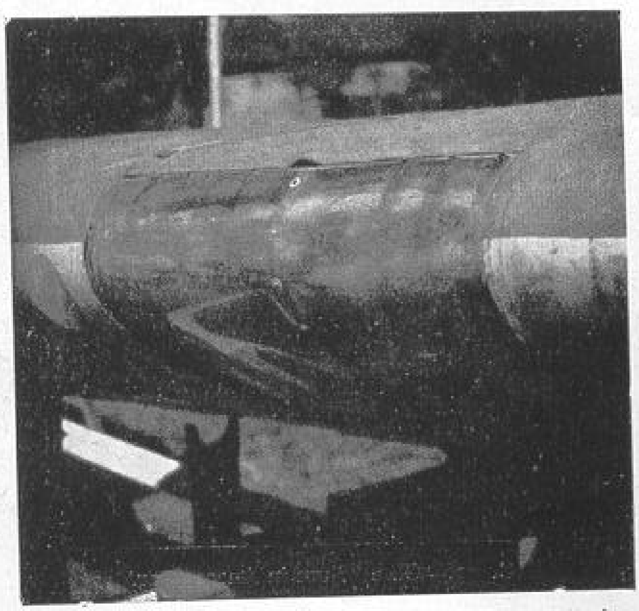

FIG. 93.—Crazing of landing light "Perspex" in Oxford port.

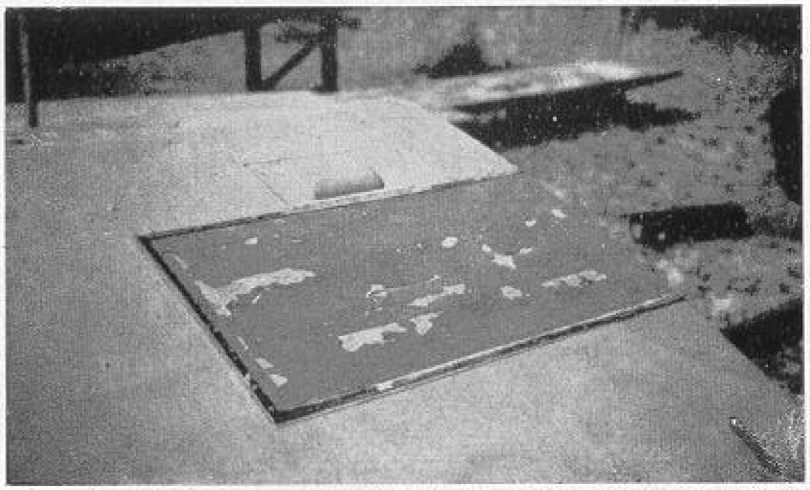

FIG. 94.—Peeling off of coating on tank cover in Oxford port.

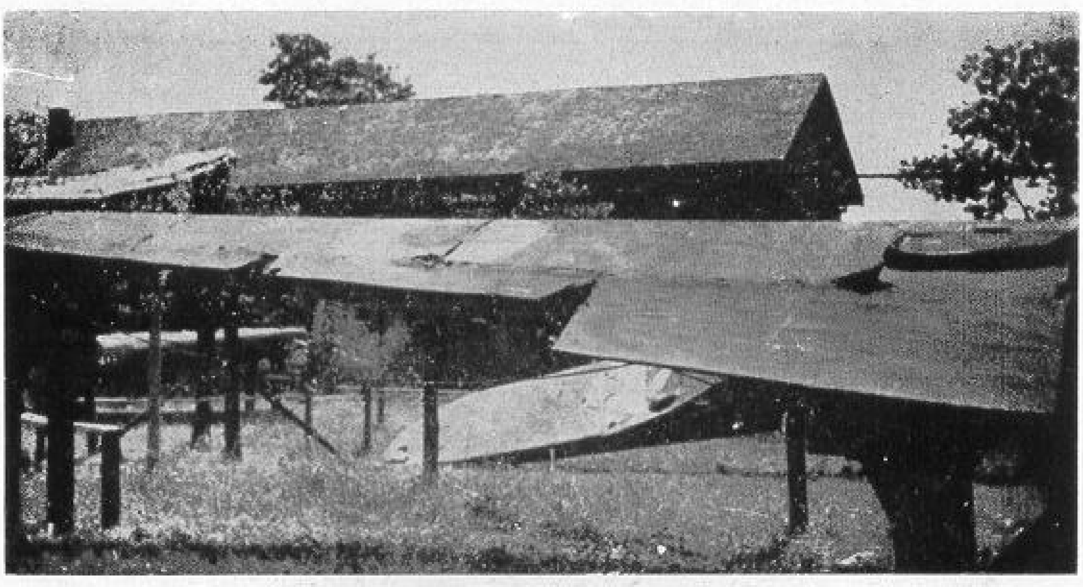

FIG. 95.—Condition of Oxford port at the end.

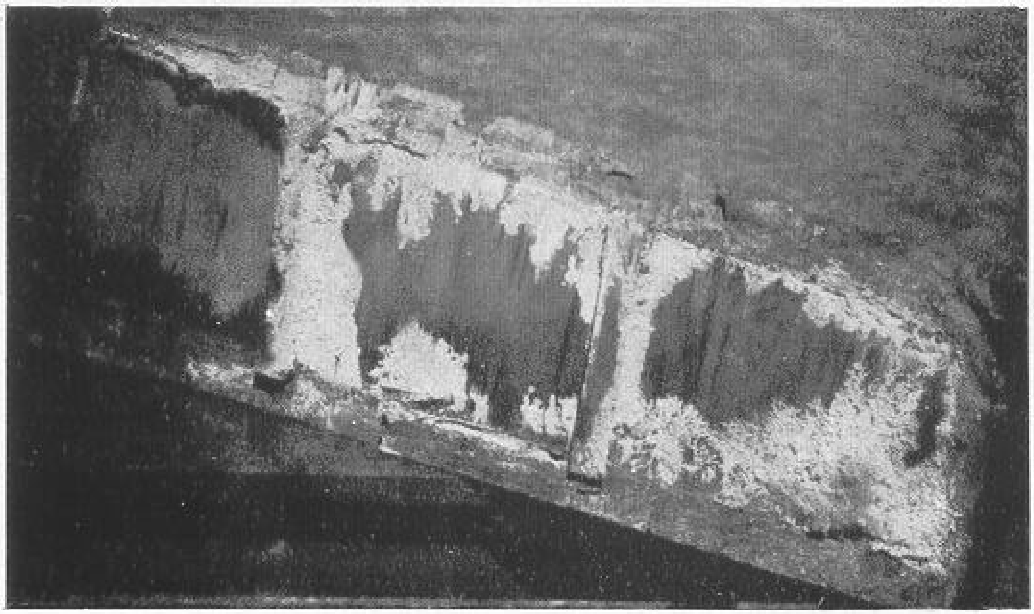

FIG. 96.—Fungus attack on birch plywood in Oxford port.

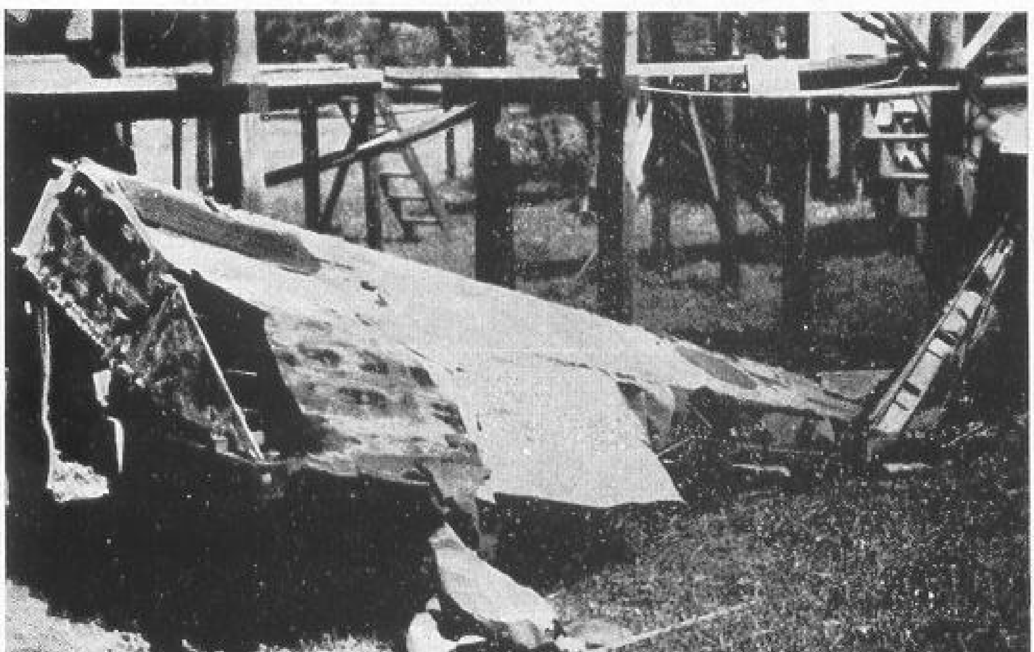

FIG. 97.—Condition of Oxford starboard at the end.

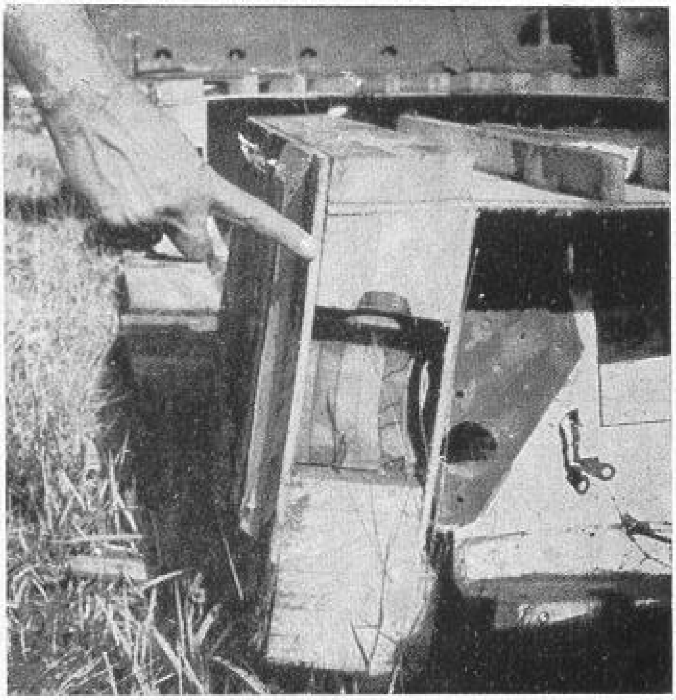

FIG. 98.—Spar web separation in Mosquito.

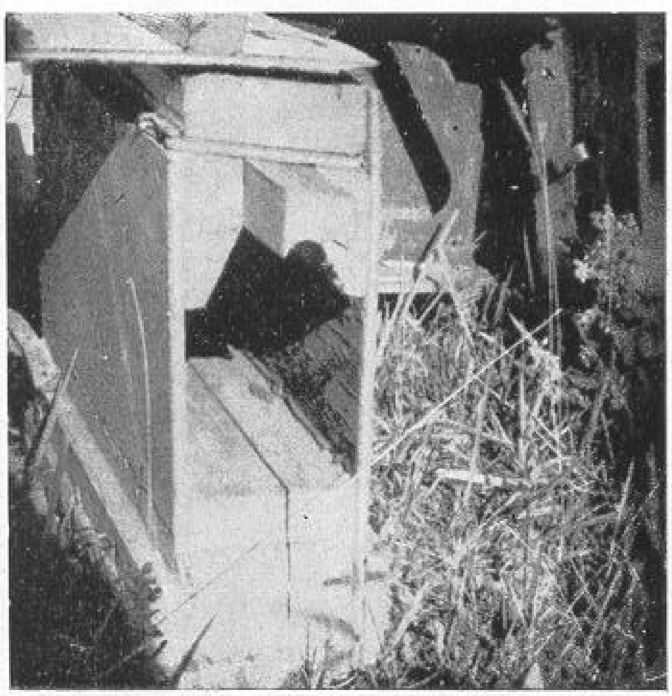

FIG. 99.—Glue failures in Mosquito.

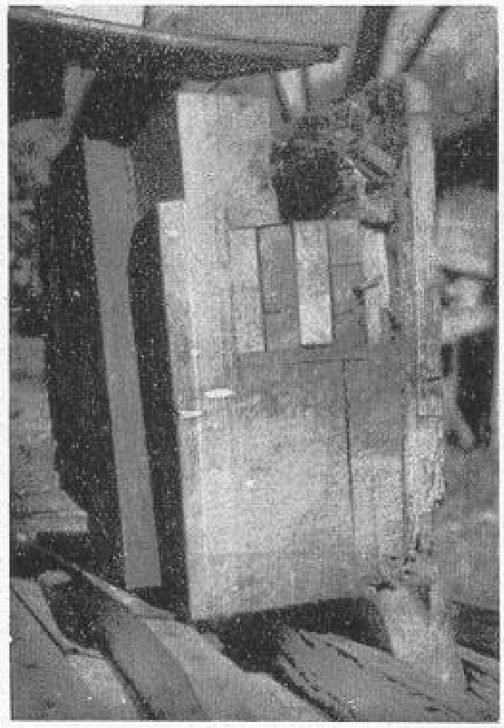

FIG. 100.—Glue failures and fungus attack in Mosquito.

FIG. 101.—General view of Mosquito mainplane starboard.

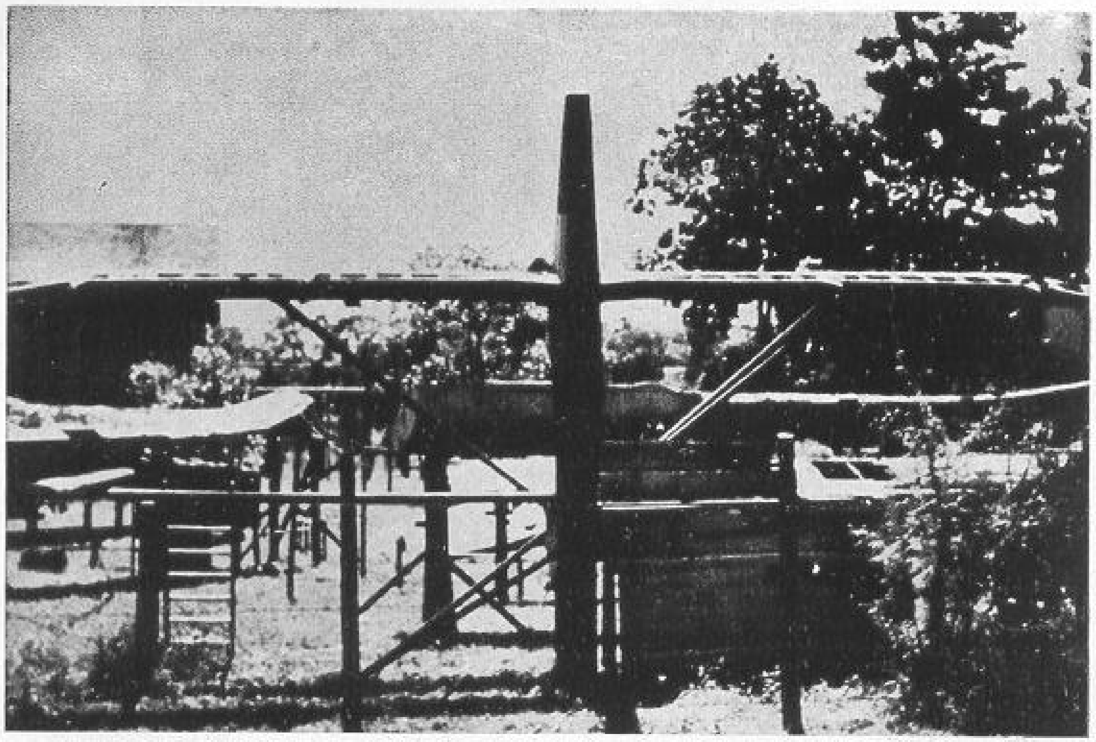

FIG. 102.—General deterioration of Horsa tailplane.

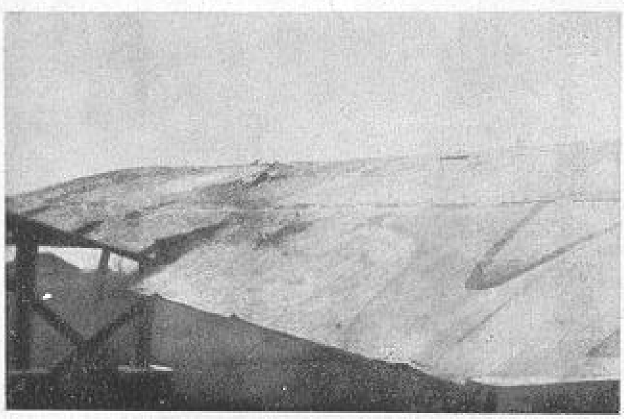

FIG. 103.—Anson starboard at Cochin at the end of 2 years' weathering.

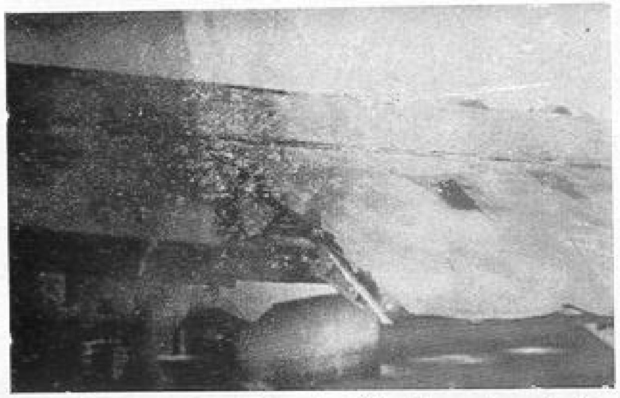

FIG. 104.—Anson starboard at Cochin at the end of 2 years' weathering.

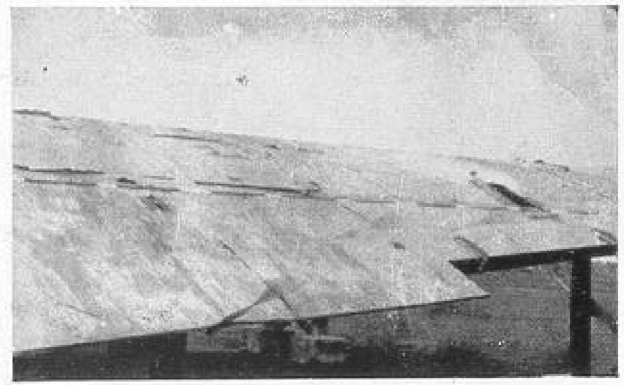

FIG. 105.—Anson Port at Cochin at the end of 2 years' weathering.

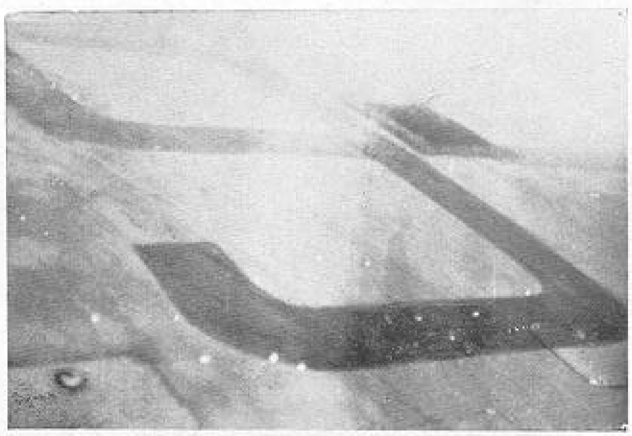

FIG. 106.—Anson Port at Cochin at the end of 2 years' weathering.

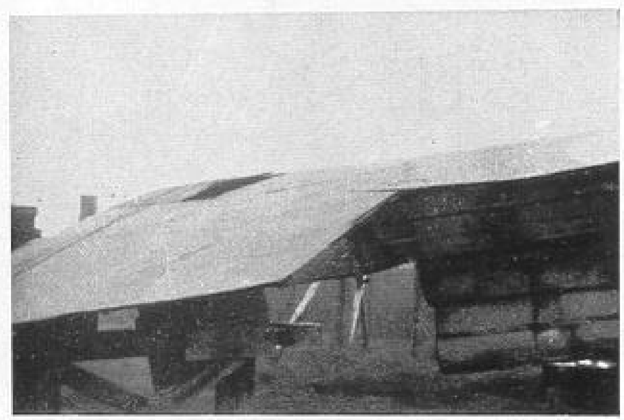

FIG. 107.—Oxford starboard at Cochin at the end of $2\frac{1}{2}$ years' weathering.

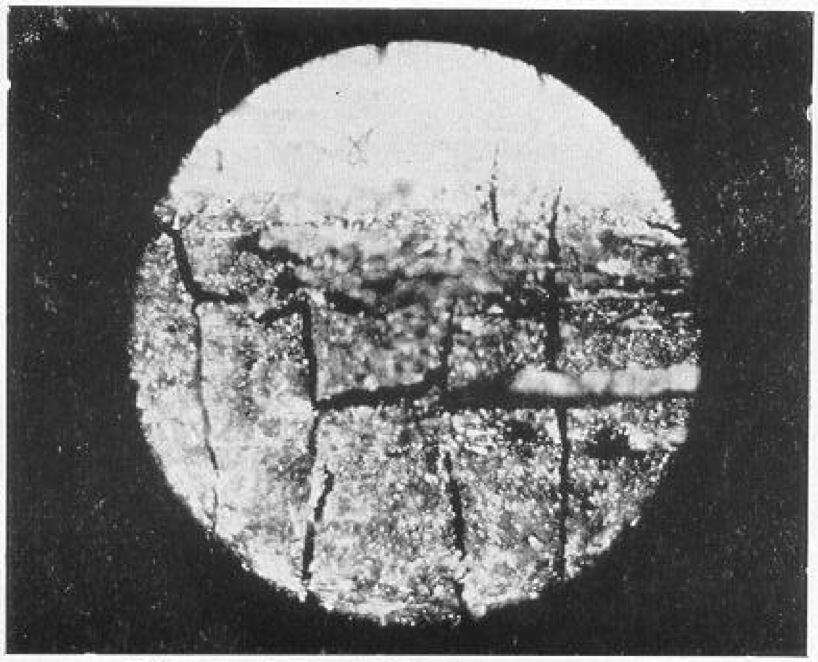

FIG. 108.—Crazing of U.F. glue line in Anson spar.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*c*) (Stress Diagm. Method)

(*Continued from the* "Indian Forester", *May 1951, page 359*)

Design for a timber bridge of span 40 feet, width 10 feet to take I.R.C. 'B' class loading, timbers used being sal (*Shorea robusta*). Grade of timber being structural No. 2 conforming to standard grade.

(A) Design of (1) Decking,
(2) Roadbearers,
(3) Transoms,
(4) Arrangement of main truss of Howe type,

remain same as that for a 40 feet timber 'through bridge' of Howe type as calculated in either

Part V(*a*) (Graphical Method) in *Indian Forester*, January, 1951

or

Part V(*b*) (Analytical Method) in *Indian Forester*, February, March, April, 1951.

(B) In the following pages, design of 40 feet span Howe truss

(1) By stress diagm. method,
(2) Calculations for Deflection of Howe truss,
(3) Requirements of timber and hardware in tabular form of a 40 feet span bridge with useful remarks for practical work in its construction,
(4) Comparison of results of sizes of members due to

(i) Graphical method,
(ii) Analytical method and
(iii) Stress diagm. method,

will be discussed.

(C) Design of 40 feet span Howe truss by Stress diagm. method :—

(1) Let

L = span of bridge divided into 8 bays
= 40 feet ; each panel length = 5 feet
D = Height of truss = $\frac{1}{8}$ of span = 5 feet.

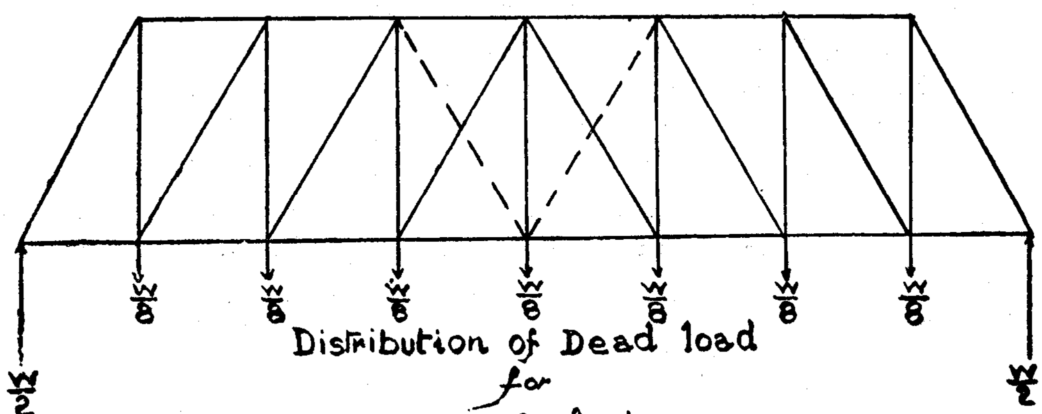
(2) Total dead load including

(i) Dead load of one truss [refer Part V(*a*) page 52, Appendix I, *Indian Forester*, January 1951]

plus dead load of half superstructure

= W say = 9 Tons [refer Part V(*a*) page 53, Appendix I, *Indian Forester*, January 1951].

(3) $\therefore$ Dead load at each panel $= \frac{W}{8} = \frac{9}{8} = 1 \cdot 12$ Tons......Fig. 127 [as per Part V(*a*), para (H) Rule 3(*a*)].



Distribution of Dead load for Trusses ≯ 80 feet span & Total load W

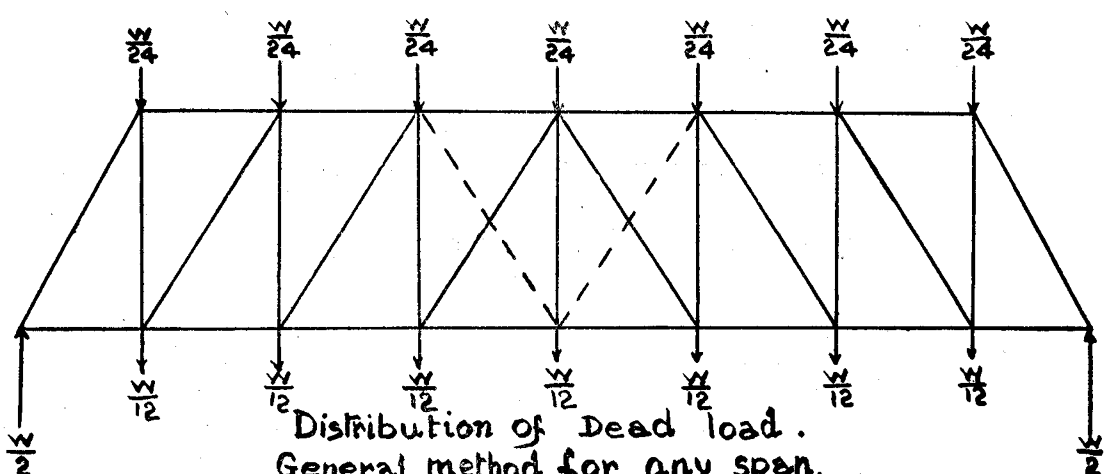
fig. 127

(4) According to common method of distribution of panel loads in a truss [refer Part V(*a*), Rule 3(*b*) page 39, *Indian Forester*, January 1951],

(*a*) $\frac{1}{3}$ total panel dead load referred to in para (C)(3) above (including that due to weight of truss) at joints of top boom

$= \frac{1}{3}$ of $\frac{W}{8} = \frac{W}{24}$ ......Fig. 128.

(*b*) The remaining $\frac{2}{3}$ of total panel dead load acting at joints of bottom boom $= \frac{2}{3}$ of $\frac{W}{8} = \frac{W}{12}$ ......Fig. 128.



Distribution of Dead load. General method for any span. & Total load W

fig. 128.

Note.—The live load on the bridge is not considered at this stage at all. When live load is considered at a later stage, it will be shown as acting

(i) At the joints of bottom boom only in case of our 'through bridge' [refer Part V(*a*) Rule 3(*b*) under (C) page 39, *Indian Forester*, January 1951].

(ii) And at the joints of top boom only in case of the design of a 'deck bridge' type of construction.

(D) Stresses (i.e., numerical value of forces) and their nature (i.e., either tensile or compressive) in different members of the Howe truss due to "Panel Dead loads" as in Fig. 127, or 128 can be readily obtained by drawing a Stress diagram Figs. 129(*a*) and 129(*b*).

(E) Explanation of drawing the Stress diagram as shown in Figs. 129(*a*) and 129(*b*) :—

Procedure by steps :

(1) Find total loads on each panel point of the truss (refer Figs. 127 and 128).

(2) Find reactions at two ends $\left(\text{here each reaction} = \frac{W}{2}\right)$.

(3) Show the Howe truss and all panel loads and reactions by a line diagram to a linear scale, [here 1″ = 10 feet for Figs. 129(*a*) and 129(*b*)] refer Figs. 129(*a*) and 129(*b*) top figs. (i.e., frame diags.).

(4) Letter each space between forces and members of the truss as shown (in capital letters). This method of lettering in engineering practice is known as Bow's notation (refer Appendix VII, page 412) Figs. 129(*a*) and 129(*b*) frame diags.

(5) Choose any suitable load scale [here 3·2″ = W for Fig. 129(*a*) and 4·8″ = W for Fig. 129(*b*)] and draw [Figs. 129(*a*) and 129(*b*) bottom, i.e., stress diags.] so that all forces (i.e., panel weights and reactions) are drawn to the chosen 'load scales' beginning with any force and going about clockwise in turn and lettering each force in small letters corresponding to the Letters it bears in the frame diags. 129(*a*) and 129(*b*), e.g., [for Fig. 129(*b*) only is given].

In stress diag. 129(*b*) we have :

(i) Load line 'jk' $= \frac{W}{12}$ corresponding to force line JK [in 129(*b*) frame diag.].

(ii) „ „ 'kl' $= \frac{W}{12}$ „ „ „ KL „ „

(iii) „ „ 'lm' $= \frac{W}{12}$ „ „ „ LM „ „

(iv) „ „ 'mn' $= \frac{W}{12}$ „ „ „ MN „ „

(v) „ „ 'no' $= \frac{W}{12}$ „ „ „ NO „ „

(vi) „ „ 'op' $= \frac{W}{12}$ „ „ „ OP „ „

(vii) „ „ 'pq' $= \frac{W}{12}$ „ „ „ PQ „ „

(viii)	Load line	'qa'	$= \frac{W}{2}$	corresponding to force line			QA	[in 129(*b*) frame diag.].	
(ix)	,, ,,	'ab'	$= \frac{W}{24}$	,,	,,	,,	AB	,,	,,
(x)	,, ,,	'bc'	$= \frac{W}{24}$	,,	,,	,,	BC	,,	,,
(xi)	,, ,,	'cd'	$= \frac{W}{24}$	,,	,,	,,	CD	,,	,,
(xii)	,, ,,	'de'	$= \frac{W}{24}$	,,	,,	,,	DE	,,	,,
(xiii)	,, ,,	'ef'	$= \frac{W}{24}$	,,	,,	,,	EF	,,	,,
(xiv)	,, ,,	'fg'	$= \frac{W}{24}$	,,	,,	,,	FG	,,	,,
(xv)	,, ,,	'gh'	$= \frac{W}{24}$	,,	,,	,,	GH	,,	,,
(xvi)	,, ,,	'hj'	$= \frac{W}{2}$	,,	,,	,,	HJ	,,	,,

[*Note.*—All the above load lines are drawn to a 'load scale' (here $4 \cdot 8'' = W$) which eventually (as will be seen later) will give us our 'Stress diags.' for members of the Howe truss].

(6) Using load line as a vertical base [see Figs. 129(*a*) and 129(*b*)], construct figures (Stress diags.) the various sides of which to the 'load scale' will represent the stresses (i.e., forces) in corresponding members of the Howe truss by drawing lines parallel to forces acting in the bars (i.e., members) of the Howe truss at every joint* in turn and taking the forces (at each joint) in clockwise direction so as to arrive finally at a close figure of the stress diags. as shown in Figs. 129(*a*) and 129(*b*) bottom figures. Each line in the stress diags. is named in small letters corresponding to the force in capital letters acting at a joint.

e.g. (1) Stress line 'hj', for force in member HJ
(2) ,, ,, 'je_1' ,, ,, ,, ,, JE_1, etc. } for Fig. 129(*b*) only.

* *Example.*—Take the right hand end bottom joint : Figs. 129(*b*) frame diag.

(*a*) Draw load lines parallel to corresponding force lines (i.e., members) meeting at the joint under consideration (i.e., right hand end joint) i.e.,

(*b*) Draw 'hj' parallel to force (here reaction) HJ. [*Note.*—It will be noticed that this load line 'hj' has already been drawn as in para E(5) above while drawing the vertical base line].

(*c*) Draw 'je_1', parallel to force JE_1 [i.e., force in the member JE_1 in Fig. 129(*b*) frame diag.].

(*d*) Draw 'e_1h' parallel to force E_1H [i.e., force in the member E_1H in Fig. 129(*b*) frame diag.].

[*Note.*—(1) All forces at any joint are taken clockwise, i.e., HJ, JE_1, E_1H about the right hand end joint.

(2) hje_1h should be a closed figure if all load lines are drawn parallel to their corresponding forces (i.e., forces in the members).

(3) Now if 'je_1' is measured to the chosen load scale, it will give us the stress (i.e., amount of force) in member JE_1. Similarly 'e_1h' gives stress in member E_1H.

(4) Now all the forces acting at the right hand end are considered].

(*e*) Again take another joint (say one next to the left of the right hand end joint).

(*f*) Repeat for this joint the load diag. as was done, by following the steps mentioned in (*a*), (*b*), (*c*) and (*d*) above.

[*Note.*—(1) '$j\ k\ c_1\ d_1\ j$' should be a closed figure.

(2) Forces at the joint are taken clockwise.

(3) Now if 'kc_1' is measured to the chosen load scale, it will give us the stress (i.e., amount of force) in member KC_1.

Similarly 'c_1d_1' gives stress in member C_1D_1
Also 'd_1e_1' ,, ,, ,, ,, D_1E_1
And 'e_1j' ,, ,, ,, ,, E_1J.

(*g*) Similarly proceed for all other remaining members of the Howe truss, taking each time a panel point and drawing stress diagm. of all forces acting on that panel point and thus finally arriving at a composite stress diagm. of all joints of the Howe truss as in Figs. 129(*a*) and 129(*b*) as the case may be.

Note.—Advantages of the stress diagm. method of solution are as follows :—

(1) Our attention is always being directed to the correctness of any assumptions that have been made,

(2) If the stress diag. closes we may safely consider the solution to be correct for the assumptions made.

(3) If the stress diag. does not close then either

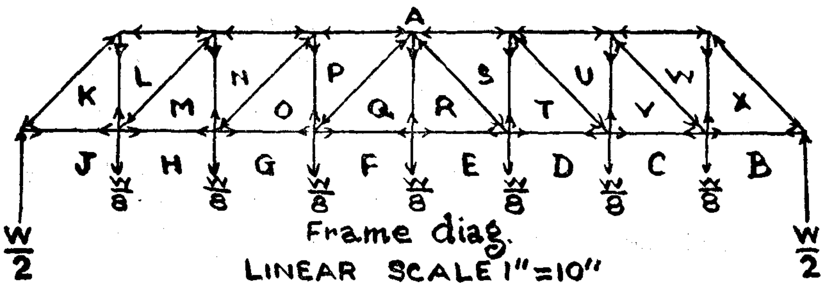
(*a*) some assumption is wrong, or

(*b*) something has been left out, or

(*c*) load lines are not drawn parallel to members representing them, etc.

(4) So far, from our stress diags. Figs. 129(*a*) and 129(*b*) we have found the amount of force each member carries in the truss.

(5) Stress diagms. of Figs. 129(*a*) and 129(*b*) give equal stresses (i.e., amount of forces) in the same member due to different mode of panel loads as in Figs. 127 and 128.

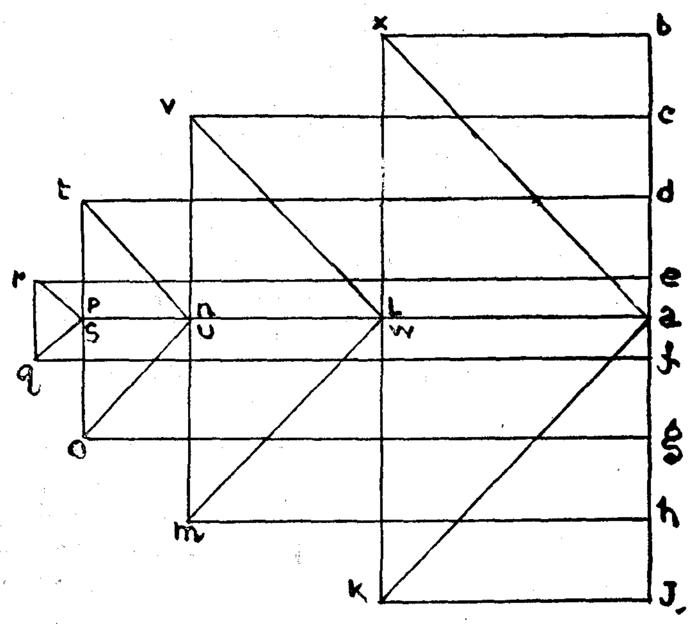


Frame diag.
LINEAR SCALE 1" = 10'

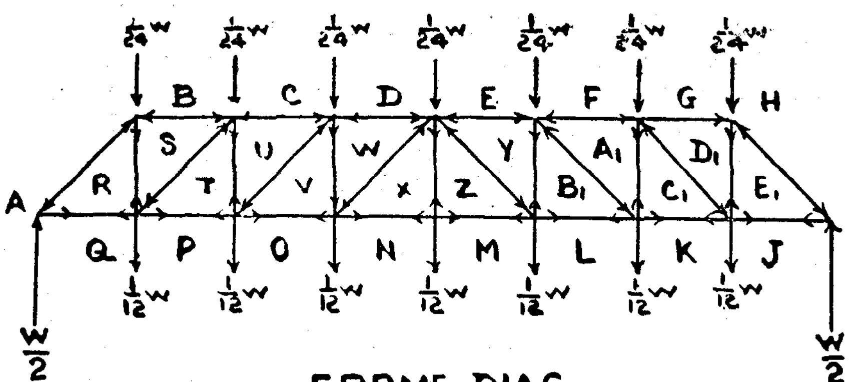
W = Actual dead load of material of Bridge comming over one truss including dead wt. of truss.
= 4.5 Tons.

or W = Twice 4.5 Tons = 9 Tons for B.M. calculations.

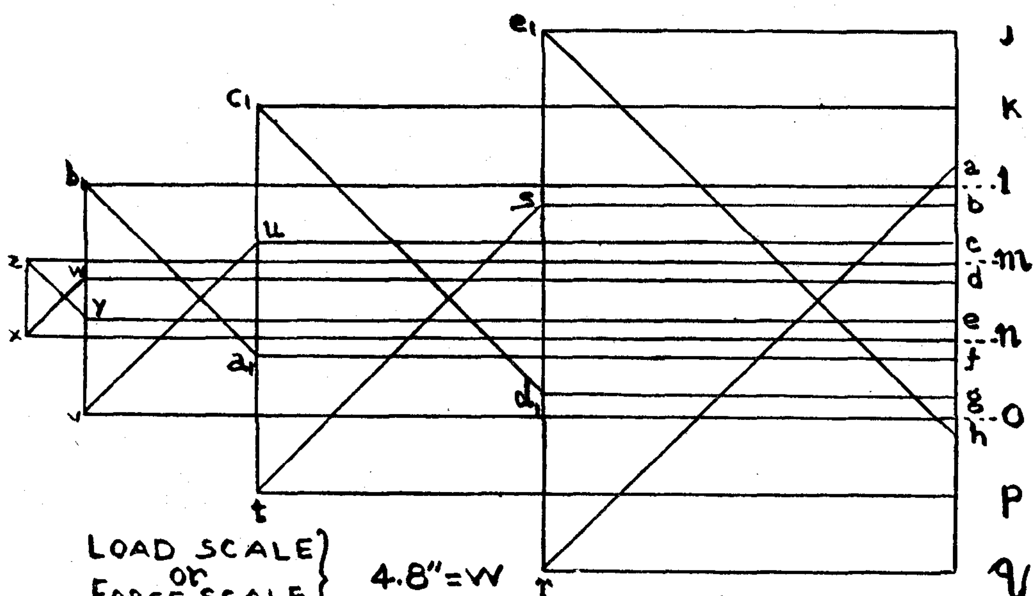
or W = Thrice 4.5 Tons = 13 Tons for Deflection calculations.



Stress diag.
FORCE SCALE 3.2" = W
fig. 129.(a)



FRAME DIAG
LINEAR SCALE 1"=10"



LOAD SCALE or FORCE SCALE } 4.8"=W

W = Actual dead load of material of Bridge comming over one truss including dead wt. of truss.
= 4.5 Tons.

Or W = Twice 4.5 Tons = 9 Tons for B.M. calculations.

Or W = Thrice 4.5 Tons = 13 Tons for Deflection calculations.

fig. 129.(b)

(F) To find 'nature of stresses' (i.e., kind of stresses) in the members of Howe truss from stress diagms. already drawn in Figs. 129(*a*) and 129(*b*).

(1) Imagine each panel point in the truss as centre of a clockface.

(2) Examine the forces at each joint in the frame diagms. in a clockwise direction.

(3) On stress diagms., observe the direction as you read each force in para (F)(2) above and go on putting the arrows near the joint in question, on the frame diagms. as indicated by the direction of the load line corresponding to that force.

(4) Repeat the steps in para (F)(3) above for all panel points of the truss.

(5) Now the directions of the arrows at the joints (i.e., panel points) show whether members are in

(*a*) Compression

or

(*b*) Tension.

(*a*) If arrow points towards a joint then the member which carries this arrow is in Compression (i.e., nature of stress is Compressive).

(*b*) If the arrow points away from the joint, the member is in Tension (i.e., nature of stress is Tensile).

(G) Thus each panel point is dealt with separately and fully to give us the forces, (i.e., stresses) in magnitude [as per para (E)] and nature [as per para (F)] acting in various members of the Howe truss due to 'Dead loads only' acting through panel points (as shown by frame diags. in Fig. 129).

(2) Consolidated result of 'stress diag.' Fig. 129(*b*) for

(*a*) Dead load forces on Howe truss is tabulated below :

TABLE I.—*For Top and Bottom Boom members for Fig. 129(b) of the Howe truss*

Member of bottom chord	Magnitude of stress in tons for Fig. 129(*b*)	Nature of stress		Member of top chord	REMARKS
		Tensile	Compressive		
JE_1	4	T	..	..	(*a*) Read the forces and members clockwise, i.e., JE_1, and not E_1J for the joint at right hand bottom end Fig. 129(*b*). Similarly D_1G and not GD_1 for the joint at right hand top end Fig. 129(*b*).
..	4	..	C	D_1G	
KC_1	6·75	T	..	..	
..	6·75	..	C	A_1F	
LB_1	8·44	T	..	..	(*b*) It will be seen that
..	8·44	..	C	YE	(1) members of the top boom are all in compression...Figs. 129(*a*) and 129(*b*) frame diags.
RQ	4·00	T	..	..	
..	4·00	..	C	BS	
TP	6·75	T	..	..	(2) members of the bottom boom are all in tension....Figs. 129(*a*) and 129(*b*) frame diags.
..	6·75	..	C	CU	
VO	8·44	T	..	..	(3) magnitude of stresses (i.e., forces) in the chords of bottom boom are equal to magnitude of stresses (i.e., forces) in the corresponding chords of top boom, e.g., $JE_1 = D_1G$; $KC_1 = A_1F$., etc., in Fig. 129 (*b*).
..	8·44	..	C	DW	
XN	9·00	T	..	..	
MZ	9·00	T	..	..	

Note.—From Fig. 129 and the above table we conclude that

(1) nature of forces in Top and Bottom chords are as were obtained in the Analytical method in Part V(*b*) para (D) and (E) pages 133 and 134, *Indian Forester*, February 1951 ;

(2) nature of forces in Top and Bottom chords are as were assumed to be correct (i.e., taken for granted) in Graphical method Part V(*a*) page 36, *Indian Forester*, January 1951 below figure 71 ;

(3) There are slight discrepancies in magnitude of stresses for same type of members (e.g., top and bottom chords) due to different methods of arriving at the stress result

[e.g., Graphical Fig. 76, page 41, Part V(*a*),
Analytical para (E)(3) page 135, Part V(*b*),
Stress diagm. para (G)(2) Table I above. Figs. 129(*a*) and 129(*b*), Part V(*c*)].

(4) Figs. 129(*a*) and 129(*b*) give identical results and thus only magnitude of stresses for Fig. 129(*b*) have been given in Table I.

TABLE II [for Fig. 129(*b*)].—*For Diagonals and Vertical members of the Howe truss*

Diagonal members	Magnitude of stress in tons	Nature of stress compressive	Remarks	Nature of stress tensile	Magnitude of stress in tons	Vertical members
1	2	3	7	6	5	4
AR		C	(*a*) Magnitude of stresses in the diagonal members decrease in magnitude as we go,	T	..	RS
=	5·63				3·75	=
E_1H		C	(1) From Left to Centre and	T		DE_1
ST		C	(2) From Right to Centre	T		TU
=	4·07				2·76	=
C_1D_1		C	(*b*) Magnitude of stresses in the vertical members decrease as we go,	T		A_1C_1
UV		C		T		VW
=	2·84		(1) From Left to Centre and		1·74	=
B_1A_1		C	(2) From Right to Centre	T		YB_1
WX			(*c*) Stresses in the verticals are equal to the vertical components of the stresses in the diagonal members meeting them at top chord.			
=	1·50					
ZY		C		T	1·08	XZ
			e.g., Stress in RS = Stress in AR × Cos ϕ			
			$\therefore S_{RS} = S_{AR} \times \cos 45°$ $\therefore S_{RS} = 5·63 \times 0·7071$ $= 3·75$			
			(*d*) Diagonals take compression ; Verticals take Tension.			

[*Note.*—From Fig. 129 and Table II above we conclude that

(1) Nature of forces in diagonals and verticals are same as were proved in the Analytical Method in Part V(*b*) paras (F) and (G) pages 135 to 140, *Indian Forester*, February 1951.

(2) Nature of forces in diagonals and verticals are same as were assumed to be correct (i.e., taken for granted) in Graphical Method Part V(*a*), page 36, *Indian Forester*, January 1951.

(3) There are very slight discrepancies in the magnitude of stresses for same type of members (e.g., diagonals and verticals) due to different methods of arriving at the results, e.g.

(*a*) Graphical, Fig. 78, page 44, Part V(*a*),

(*b*) Analytical, paras (F) and (G) pages 135 to 140, Part V(*b*), and

(*c*) Stress diagms. para (G)(2), Table II above and Figs. 129(*a*) and 129(*b*), Part V(*c*).

(4) Figs. 129(*a*) and 129(*b*) give identical results and thus only magnitude of stresses for Fig. 129(*b*) have been given in Table II above].

(H) Stresses (i.e., numerical value of forces) and their nature (i.e., either tensile or compressive) in different members of Howe truss due to

Moving load (i.e., live load)

by Stress diag. method :—

Procedure by steps :

(1) Find equivalent uniformly distributed dead load corresponding to the moving live load of a 10-ton roadroller moving one at a time over the bridge from Part V(*b*), para (B)(3) to (5) page 131 and 132 of *Indian Forester*, February 1951. It is found to be,

E.U.D.D.L. = 20 Tons = 44800 lb. = W_1 say.

(2) Assume this live load (now changed to E.U.D.D.L.) to be acting at the joints of bottom boom [refer Part V(*a*), Rule (3)(*b*) (C)(i) page 39, *Indian Forester*, January 1951].

(3) Now find the ratio of live load to dead load

$$\text{i.e., } \frac{\text{Live load}}{\text{Dead load}} = \frac{\text{E.U.D.D.L.}}{\text{Dead load}} = \frac{W_1}{W} = \frac{20 \text{ tons}}{9 \text{ tons}} = 2 \cdot 2 = Y \text{ (say).}$$

(4) Now E.U.D.D.L. act on the truss exactly as the dead load acting on the truss (as per para Fig. 128) but are $2 \cdot 2$ times greater than the panel dead loads acting at the joints of bottom boom.

(5) Therefore by multiplying the dead load stress as given by Fig. 129 or Tables I and II in different members of Howe truss by the ratio 'Y', i.e., $2 \cdot 2$, we obtain,

Stresses (i.e., numerical values of forces) and their nature in different members of the Howe truss due to moving load of a 10-ton roadroller.

(6) Consolidated result of stresses in different members of Howe truss due to (*b*) moving load is tabulated below :—

TABLE III.—*For Top and Botom booms, Diagonals and Vertical members of Howe truss*

Member of Howe truss named as per Fig. 129(*b*)	Magnitude of dead load stress in tons, either from Figs. 129(*a*) or 129(*b*)	Multiplying factor 'Y' to arrive at live load stress	Magnitude of live load stress in tons	Magnitude of dead and live load stresses in tons	REMARKS
1	2	3	4	(2)+(4)	Refer Fig. 129(*b*)
Bottom boom : (tensile)					(*a*) We notice that bottom chord XN carries the max. combined (dead and live load) stress of all the other bottom chord members. We shall for safe and quick design, calculate the size of the whole bottom boom on the max. stress carried by XN.
RQ	4·00	2·2	8·80	12·8	
TP	6·75	,,	14·85	21·5	
VO	8·44	,,	18·56	27·0	
XN	9·00	,,	19·80	28·8	
Top boom : (compressive)					(*b*) Top chord member DW carries max. combined (dead and live load) stress of all the other top chord members. We could for safe and quick design calculate the size of top boom on the max. stress carried by DW.
BS	4·00	2·2	8·80	12·8	
CU	6·75	,,	14·85	21·5	
DW	8·44	,,	18·56	27·0	
Diagonals : (compressive)					(*c*) Diagonal AR carries the max. combined (dead and live load) stresses of all the other diagonals. We shall for safe and quick design, keep the sizes of all diagonals on the basis of the size arrived at for diagonal AR.
AR	5·63	2·2	12·39	18·02	
ST	4·00	,,	8·80	12·80	
UV	2·84	,,	6·24	9·08	
WX	1·50	,,	3·30	4·80	
Verticals : (tensile)					(*d*) Verticals RS carries the max. combined (dead and live load) stresses of all the other veticals. We shall for safe and quick design, keep the sizes of all verticals on the size arrived at for vertical RS.
RS	3·75	2·2	8·25	12·00	
TU	2·76	,,	6·07	8·83	
VW	1·74	,,	3·82	5·56	
XZ	1·08	,,	2·27	3·43	

(J) Counter bracing :—

(1) Follow exactly the same method as given in Part V(*a*) Graphical Method, para (L), page 45 of *Indian Forester*, January 1951 or

(2) Follow exactly the same method as given in Part V(*b*), Analytical Method, para (M), page 198 of *Indian Forester*, March 1951.

(3) Thus we see that the counter-braces are required in 4th and 5th panels.

(K) (*a*) Results of stresses (i.e., forces) in different members of Howe truss arrived at by three different methods of solution, appear to vary only slightly as seen from table below :—

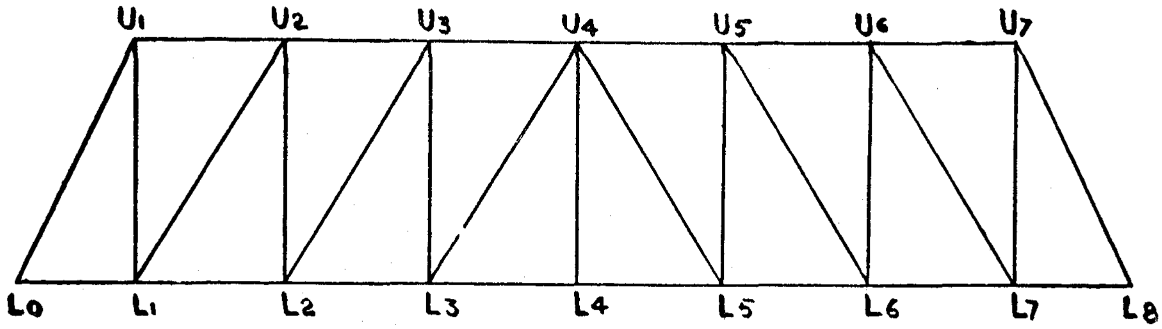


fig. 130.

TABLE IV

Members of Howe truss named from Fig. 130	Total (Dead plus live load) stresses in members of the Howe truss arrived at by		
	Graphical Method Part V(*a*)	Analytical Method Part V(*b*)	Stress Diagm. Method Part V(*c*)
	Refer Figs. 76, 78, Stage III	Refer Fig. 126	Refer Table III and also Fig. 129(*b*)
	Page 41 and 44	Page 357	Page 401
	Tons	Tons	Tons
Bottom boom :			
$L_0 L_1 = L_7 L_8$ ..	11·25	12·88	12·80
$L_1 L_2 = L_6 L_7$ ..	20·80	22·07	21·50
$L_2 L_3 = L_5 L_6$ ..	24·80	27·57	27·00
$L_3 L_4 = L_4 L_5$ ..	27·75	29·30	28·80
Top boom :			
$U_1 U_2 = U_6 U_7$ ..	11·25	12·88	12·80
$U_2 U_3 = U_5 U_6$ ..	20·80	22·07	21·50
$U_3 U_4 = U_4 U_5$ ..	24·80	27·57	27·00
Diagonals :			
$L_0 U_1 = L_8 U_7$ ..	17·00	18·22	18·00
$L_1 U_2 = L_7 U_6$ ..	12·37	13·45	12·80
$L_2 U_3 = L_6 U_5$ ..	8·25	9·12	9·08
$L_3 U_4 = L_5 U_4$ ..	4·00	5·24	4·80
Verticals :			
$L_1 U_1 = L_7 U_7$ ..	11·63	12·04	12·00
$L_2 U_2 = L_6 U_6$ ..	8·20	9·12	8·83
$L_3 U_3 = L_5 U_5$ ..	5·50	6·06	5·56
$L_4 U_4$ ..	3·00	3·92	3·43

(*b*) We have already calculated the sizes of Bottom boom, Top boom, Verticals and Diagonals on the results of stresses arrived at by Graphical Method in Part V(*a*), paras (N), (P), (Q) and (R), pages 48 to 52, *Indian Forester*, January 1951.

(*c*) We will use these sizes in calculations of actual deflection of the truss under dead plus live loads [later on in this artical in para (N), Table VII].

APPENDIX VII

[Refer Part V(*c*), para (E)(4), page 403, *Indian Forester*, July 1951]

A simple example of Bow's method of lettering a system of forces in a structure :—

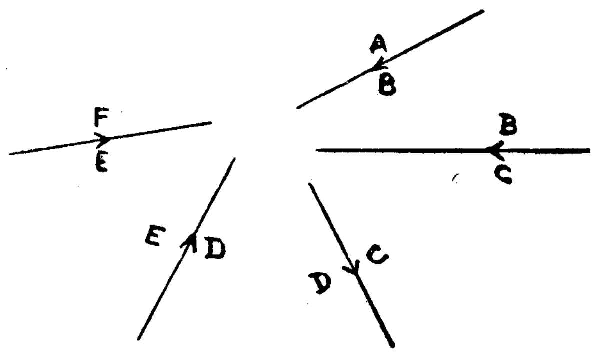
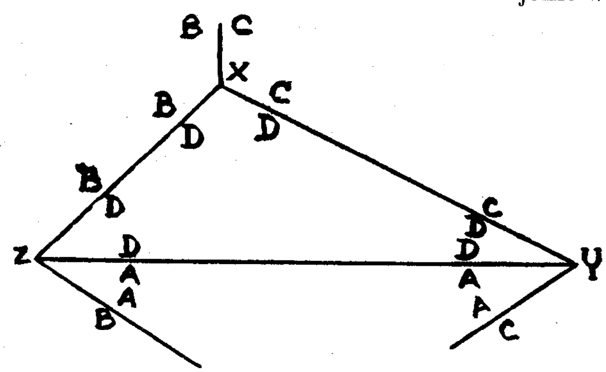


fig. 7.
(Appendix)

We see from the above figure that every force has one letter on each side of its line of action. This is one way of naming the force. Thus we speak of the forces AB, BC, CD, DE and EF (Notice that we name forces clockwise around a joint where they act).



Theoretical way of naming Forces.
fig. 8. (appendix.)

From the above Fig. 8 we have the forces acting at the joints of a triangular frame XYZ named after Bow's method stage I (i.e., theoretical way of naming forces).

The forces (in Fig. 8) which keep in equilibrium the joints X, Y and Z are :—

(*a*) For the joint X :

The force BC (all the elements of which are known),
The action of force CD, and
The action of stress DB.

Note.—For the complete specification of 'force' we must know the following three elements :—

(1) The line of action, i.e., the line along which the force is acting,

(2) The direction (or way) the force acts along its line of action,
and (3) The magnitude, i.e., number of units of force.

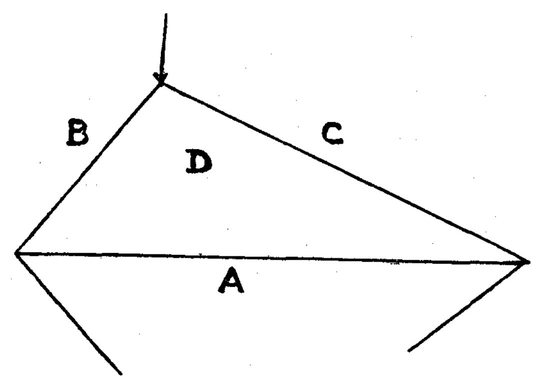
(b) For the joint Z:
The action of the force BD,
The action of the force DA, and
The action of the supporting force AB.

(c) For the joint Y:
The action of the force AD,
The action of the force DC,
The action of the force CA.

The point X might be called the joint BCD,
The point Y ,, ,, ,, ,, ,, CAD, and
The point Z ,, ,, ,, ,, ,, ABD, since the letters naming a joint have been used to name the forces acting at the joint.

In Fig. 8 we have used the letters A, B and C each four times and the letter D six times.

In practice, this is avoided by lettering as indicated in Fig. 9 below as per Bow's method in practice.



Bow's method in practice.
Fig. 9.

It will be seen that external forces and internal forces in the members of the frame have (i.e., retain) the same names as previously indicated as per Fig. 8.

Success in graphical solution by 'Stress diagram method' depend in a great measure,

(1) on correct lettering of forces by using Bow's method of notation in clockwise direction, and

Note.—Correct lettering is accomplished when every external force and every member of the structure have one letter and one only on each side of them.

(2) on correct assumptions having been made with regard to
(a) total number of external forces acting on the frame, and
(b) what is known about the various elements of these external forces.

(To be continued)

NOTE:—Separate copies of this article can be obtained from the P.L.O.. F.R.I. and Colleges, Dehra Dun on payment.

FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

BY PROFESSOR E. P. STEBBING, M.A.

(Fellow of the Linnean Society, Fellow of the Royal Geographical Society, Fellow of the Royal Society of Edinburgh. Honorary Member of the Society of American Foresters, formerly of the Indian Forest Service, now Head of the Department of Forestry, University of Edinburgh)

PART II

(*Continued from* The Indian Forester, *June 1951, page 392*)

AFRICA

General Notes on EAST and WEST AFRICA

The part of Africa, south of the Sahara from Senegal to the Sudan has many characteristics in common, the regions perhaps of chief importance and most discussed lying from Sierra Leone to the Sudan. Between, are situated the Liberian State, the Ivory Coast, Haute Volta, Gold Coast, French Soudan, Togoland, Dahomey, Nigeria, French Niger, the Cameroons, French Equatorial Africa, Belgian Congo, the East Africa colonies of Nyasaland, Tanganyika, Uganda, Kenya and the Egyptian Sudan to the north. From half to two-thirds of this great area of Africa is covered by the so-called bush or savannah, variously degraded from a former high forest, becoming more open and of thorn-like character as it goes north on the confines of the Sahara including Libya. The method of farming depending upon the bush is the method known as shifting cultivation—but the villages are fixed and the Chief and his people practise this method on a definite area of country in their proprietorship. Population and stock may increase in numbers, but the area of land remains a constant. The result is that the fallow period or number of years intervening between cultivating and re-cultivating the same site becomes shorter and the return of the crops poorer in amount and value. Added to this the climate becomes drier and the rainfall shows an intermittency. This is no new thing. It has certainly happened in the past centuries and we are only witnessing an often repeated story in the world's history; but owing to a settled government the rate of the desiccation and interference with man's pursuits is becoming more rapid.

The tsetse fly also adds to the difficulties of the land problem in some parts.

EAST AFRICA

NYASALAND

Attention is drawn to the fact that in both East and West Africa large areas of the countryside are covered with the so-called bush or savannah growth—a degenerate type of former high forest and that this bush is utilized by the population on a system of shifting cultivation or 'farming', crops being taken off an area which is felled and the material burnt, the ash being spread over the area and a crop sown. This practice is carried on for 3-4 years, the area then lying fallow for a varying period of years to allow the bush to grow up again.

With the smaller populations of former and not so distant times, the period of fallow, 30–50 years or more was long enough to enable the bush to reach a size which provided, when burnt, a considerable area of wood ash. Now-a-days, in many parts of East and West Africa

the population has greatly increased but the area of land owned by the Chief and his villagers has remained a constant. Consequently, the period of fallow is greatly shortened and becoming briefer, with a natural result that the yield of crops is less, exposure is greater and increasing aridity and the sinking of the spring water level of the water in the ground is becoming accelerated.

Mr. C. Vigne, the Conservator of Forests, Nyasaland, in reply to my questionnaire writes—

"I can give little information of value. Nyasaland is not mapped. There is a general map. The Shire is the only sizable river and it is not large.

"The Shire, in Nyasaland, is approximately 220 miles long, for the last 50 miles it forms the boundary with P.E.A. It flows south from Lake Nyasa and after 8 miles through flat country expands into a shallow lake for 20 miles ; no fringing forest. It then flows through flattish country for approximately 50 miles, with generally a little fringing forest on the banks, often only a few trees. For the next 60 miles it narrows and drops over a series of rapids, and the fringing forest is somewhat better, but poor. It then flows for 80 miles through flat country, much of which is flooded yearly, with practically no fringing forest.

"The paucity of fringing forest is, I think, due to the following : (*a*) long dry season and annual fires, (*b*) pressure of population in places and concentration near water and desire to farm fertile soil on the river banks, (*c*) to exploitation, specially for canoes, for which large trees are needed and are found in fringing forest, (*d*) to flooding and swamp conditions. In Nyasaland, it is an offence to cut trees without permit or to farm in the 'Protected Strip' which is 8 yards wide from the upper edge of the bank for streams over 8 yards wide. But much of the damage had been done in the past, and is continuing as it is not possible to control the whole country.

"The smaller rivers and streams—and Nyasaland is quite well watered, have in the aggregate a considerable amount of fringing forest, but always very narrow".

This answers so far as possible the questionnaire.

KENYA

Mr. E. W. Carroll (for Conservator of Forests) writes—

"It is undoubtedly true to say that there are no rivers in Kenya fit to be included among 'the larger rivers in Africa'. The Colony's waterway most deserving the name of 'river' is the Tana River which is some 500 miles in length, rising in the Aberdare Mountains and Mount Kenya and flowing in due course into the Indian Ocean. It is estimated that along the 500 miles of the Tana River there are some 150 miles of fringing forest and some 300 miles of fringing woodland and fringing scrub. These are in their natural form except in a few areas where clearing of undergrowth has been done as an anti-tsetse measure".

It would have been of interest to have known something about the Juniper forests in Kenya and the catchment areas of the rivers flowing through these forests. Also on the stretches of bamboo forest at the upper elevations on the mountains and their effect on preserving the water in the higher catchment areas. The paucity of Forest Staff in Kenya over a period of years may have made it impossible to make this study, a vital one in the interests of the Colony.

In March 1950 I received a letter from Mr. M. F. Abraham who graduated B.Sc. in Forestry (Edinburgh) in July 1948 and was appointed Assistant Conservator of Forests in Kenya Colony. He wrote :—

"Since I came to Kenya I have been stationed in the South Mount Kenya Forest Reserve, an area consisting of evergreen Temperate Rain Forest, with tracts of secondary growth. The Reserve is characteristically broken up into numerous ridges, all with steep valleys in which fast-flowing mountain streams are to be found and until very recently was an 'unknown area'. The main species are *Ocotea usambarensis* (East African Camphor) and *Podocarpus milanjianus* (Podo) ; the majority of the Camphor being found on the slopes of the ridges. In addition a great number of hardwood species are to be found, few of which, at present, have a commercial value.

"The work involved has of course been very varied and always interesting. I began by building a bungalow and have since had to construct many miles of roads, bridges, etc. Enumeration surveys for a very preliminary Working Plan have taken up a lot of time and I am at the moment collecting data for a study of the Autecology of Camphor. In the bounding Native Reserve, we have tried to preserve their over cut forests by creating a Green Belt. The manner in which vegetation cover is a regulator of seasonal water flow, as well as of total discharge, has amazed me. In one particular area a dried-up spring was producing a regular supply within 18 months of a tree crop being planted on the ground. I also believe in the contention that forests influence local rainfall".

This appears to me evidence that the modern type of young Forest Officer will take seriously problems of this kind which have been with exceptions, practically ignored in the past.

UGANDA

The Conservator of Forests, Dr. W. J. Eggeling, commences his reply to the questionnaire "Your letter is somewhat of a poser", a similar remark to one I had already received from the United States, and elsewhere.

"In this territory we have relatively few large rivers and most of our fringing forest, fringing woodland and fringing scrub is actually found along the lesser rivers and see page lines, often completely dry on the surface for much of the year. The amount of this vegetation is quite impossible to estimate. Generally speaking, little of our fringing vegetation is wider than 50–300 yards on either bank. The following are the only figures I would care to put forward, and those very tentatively :—

	miles
Kagera River	25
Victoria Nile	100
Aswa River	50
Albert Nile	5
Mpanga River	20
Sezibwa River	20

Much of this is just a narrow strip, scarcely to be dignified as 'forest' ".

It would have been interesting to know how much felling has been done in the forest on the catchment areas of the mountains. Presumably this information is not yet available.

TANGANYIKA

In the Geographical Review published by the American Geographical Society a paper by the late Clement Gillman was featured entitled "A Vegetation-Type Map of Tanganyika Territory". The manuscript, map and text were received at the American Geographical Society in November 1946 a month after the death of the author. Gillman appears to have started work in Tanganyika in 1913 and had accumulated a great deal of information on people and vegetation. A note at the beginning of his last paper on Vegetation-Types as published in the Review says—"The map crowns a career devoted to geography and East Africa—to vanquishment of "splendid ignorance by unassailable facts. But if Gillman was constantly warring against the legend or obsession of "Africa's untold wealth" his efforts were in themselves constructive; he sought to lead to a "sounder optimism based on the search after knowledge which sees hope for Man, even in semi-arid Africa, through his adapting himself to an inexorably stern Nature without further wanton destruction, by learning and facing the facts".

It is difficult to imagine when this idea or legend of *Africa's untold wealth* has come from. It has had a strong revival since the cessation of the Second World War.

The following concluding summary paragraphs are the last the author wrote :—

"*Forest Remnants.* Of equal, or perhaps even greater, urgency is the threat to the country's water resources through the destruction of the evergreen forests on the main watersheds. The vegetation map brings out instructively the pitifully small remnants of forest by the use of solid black for an "eye-opener"—and many of the black patches had to be exaggerated to make them visible at this small scale.

"The geographer should never tire of pointing out, with all the scientific emphasis at his command the important interrelations between the small still-forested uplands and the vast foot plains. The plains can remain, or again become, the home of a stable peasantry only if the forests are protected against the rapacious inroads of the mountain dwellers and if their rehabilitation is energetically furthered without delay in the many areas where deterioration is advanced.

"*Alien Plantations and Native Land Occupation.* Another salient point on the map, rectifying a commonly held exaggeration, is the insignificance of the alien plantations and farming settlements, not only when compared with the total surface, on which these tiny specks of land—coloured bright red for emphasis—literally almost disappear but even when contracted with the extent of native land use. However, unpalatable this fact may be to the politician and the land speculator, the geographer studying the vegetation map cannot fail to draw the inevitable conclusion and follow them up with his warning voice".

The answers sent to the questionnaire by Mr. H. Fraser, (for the Conservator of Forests) are amongst the best and most comprehensive received. "The knowledge of the types and extent of fringing vegetation along the whole course of our larger river is far from complete but the following is a picture of the types found based on observations in the more accessible regions".

"In general our larger rivers rise on the eastern slopes of the higher mountain ranges which being exposed to the monsoon winds have the highest rainfall. They have their sources in the temperate rain forest and traverse tropical rain forest on the lower slopes before entering the drier long grass savannah regions lying between the mountains and the sea. Owing to the presence of sub-soil water gallery forest of the rain forest type containing such trees as *Khaya, Entandrophragma* and *Chlorophora* extend along the banks through the surrounding dry savannah. As conditions become

drier through lower rainfall, or through seasonal decrease in stream flow, the vegetation alters from gallery forest to dense thicket, and under very dry conditions the river may traverse grassland with scattered *Acacias* or *Combretum* with little thickening of vegetation along the river banks. The fringing vegetation is also influenced by topography and in low-lying country subject to seasonal flooding the natural vegetation is a tall elephant grass (*Phragmites communia*) devoid of trees or woody shrubs. As the higher rainfall area of the coastal belt is reached, the fringing vegetation again thickens up and under favourable conditions gallery forest containing tropical rain forest species again appears. Finally, the larger rivers enter the sea through deltas traversed by numerous creeks the tidal waters of which are bordered by the mangroves, *Rhizophora mucronata, Bruguiera gymnorrhiza, Ceriops candolleana, Avicennia officinalis, Sonneratia acida*, and *Xylocarpus benadirensis*.

"I give below the details required regarding the larger rivers of the territory. Of these the Pangani, Umba, Ruvu, Rufiji, Matandu, Mbemkurum Lukuledi and Rovuma, flow eastwards to the Indian Ocean".

1. *Ruvu or Pangani.* The Ruvu rises on the southern slopes of Mount Meru but the greatest volume is derived from the numerous tributaries flowing from south and east Kilimanjaro. The first 10 miles of the major tributaries which go to form the Ruvu River traverse temperate rain forest. Fringing forest of the tropical rain forest type continues for approximately another 20 miles giving place to thicket as the drier zones are reached. These conditions continue for 160 miles until the river enters the higher rainfall areas induced by the neighbouring Usambara Mountains. Here fringing forest reappears and continues for the remaining 70 miles until mangroves are entered in the tidal waters of the Pangani estuary. The total length of the river including tributaries is estimated to be 730 miles. The various types traversed can, therefore, be analysed as follows :—

	miles
Forest and fringing forest ..	.. 250
Fringing woodland ..	.. 320
Fringing scrub ..	.. 155
Mangroves ..	.. 5
	730

South of Kilimanjaro the country is sparsely populated along the course of the river and cultivation is negligible.

2. *Umba.* The Umba rises in the Western Usambara Mountains in temperate rain forest. Fringing forest continues for about 20 miles of its length when with drier conditions there is a transition to thicket and fringing scrub for about 30 miles until the higher rainfall areas of the coastal belt is reached and fringing forest reappears. Mangroves occur in the estuary.

The total length of the river is 80 miles and vegetation can be apportioned as follows :—

	miles
Forest and fringing forest ..	.. 20
Fringing woodland ..	.. 30
Fringing scrub ..	.. 25
Mangroves ..	.. 5
	80

Cultivation along the course of the river is negligible.

3. *Wami.* The Wami is fed by numerous tributaries arising in temperate rain forest in the Nguru Hills. It traverses a fairly high rainfall area and fringing forest of the tropical rain forest type continues into the plains where under drier conditions the surrounding vegetation changes to *Combretum-Acacia* savannah with thicket along the banks. In the coastal belt fringing forest reappears and the river finally enters the sea through mangrove swamps. The total length of the river including major tributaries is 400 miles which can be apportioned to the various types as follows :—

		miles
(i)	Forest and fringing forest ..	350
(ii)	Fringing woodland	40
	Mangroves	10
		400

4. *Ruvu.* The Ruvu rises in temperate rain forest in the Uluguru Mountains as the Mgeta River flowing south, and is joined by the Ngerengere flowing north from the Ulugurus. The total length of the river including major tributaries is approximately 380 miles. It traverses a fairly high rainfall area and fringing forest occurs throughout its course except where the banks are low and seasonal flooding occurs.

The various vegetation types can be apportioned as follows :—

	miles
Forest and fringing forest	300
Fringing woodland	30
Fringing scrub	45
Mangroves	5
	380

5. *Rufiji.* The Rufiji River which enters the Indian Ocean about 100 miles south of Dar-es-Salaam is fed by four great river systems :—

(*a*) The Njombe-Kizigo,
(*b*) The Great and Little Ruaha,
(*c*) The Ruhuji-Kilombero,
(*d*) The Luwego-Mbarangandu.

The climatic zones through which these rivers pass are so varied that it is necessary to deal with each separately.

(*a*) *The Njombe-Kizigo system* rises in the dry central plateau at about 5,000 feet. To its junction with the Great Rusha it is seasonal and dry for about 6 months of the year except for isolated pools. It traverses the *Brachystegia-Isoberlinia* savannah typical of the extensive dry areas of the territory at altitudes of 2,000–4,000 feet. The fringing vegetation along seasonal water courses in generally dense thicket in which the following trees are commonly found—*Erythrophleum guineense*, *Tamarindus indica* and *Ficus* spp. The total length of the Njombe-Kizigo system is estimated to be 700 miles with fringing thicket throughout its course.

(*b*) *The Great and Little Ruaha system.* The Great Ruaha rises in temperate rain forest on the northern slopes of Rungwe Mountain and the Poroto Range only 30 miles north of Lake Nyasa. On the lower slopes fringing rain forest occurs, but on reaching the lower dry levels of the Usangu plains, where seasonal flooding occurs, the surrounding country is *Acacia* savannah and the river banks fringed with thicket. The Little Ruaha rises in temperate rain forest of the Uzungwa Range. It traverses mountain grassland at altitudes of 6,000—5,000 feet where little fringing forest occurs and the banks are clothed with scrub. The major tributaries arising in temperate rain forest ensure a perennial flow, although the Ruaha system traverses dry savannah to its junction with the Kizigo and for some 50 miles below when it comes under the influence of the higher rainfall areas induced by the Ukwama-Nyumbanitu Range and fringing forest re-appears. High rainfall conditions continue and the Ruaha traverses the rain forest type until it joins the Rufiji.

The total length of the Great Ruaha and Little Ruaha river system is 1,300 miles and it is estimated that different types of fringing vegetation are distributed as follows :—

	miles
Forest and fringing forest ..	.. 600
Fringing woodland ..	.. 300
Fringing scrub ..	.. 400
	1,300

(*c*) *The Ruhuji-Kilombero system.* The Ruhuji rises in temperate rain forest in the northern slopes of the Livingstone Range and is fed by numerous tributaries from the temperate rain forest of Uzungwa on the north-west and from the Mahenge Massif on the south-east. The Ruhuji and its tributaries combine to form the Kilombero which traverses the area of high rainfall induced by the Uzungwa Escarpment and the Ukwama-Nyumbanitu Mountains. At altitudes over 4,000 feet the river and tributaries traverse temperate rain forest which changes to the tropical rain forest type when lower levels are reached. Throughout the Kilombero valley the natural vegetation type is tropical rain forest but the fringing vegetation is influenced by topography and for about 150 miles of its length, owing to seasonal flooding, the vegetation to a considerable width on both banks is long grass through which are scattered *Borassus* and *Hyphæne* palms. For about 100 miles before its junction with the Ruaha the course of the river is more confined and fringing forest of the tropical rain forest type again appears.

The total length of the Ruhuji-Kilombero system is 1,000 miles and the different types of fringing vegetation are distributed as follows :—

	miles
Forest and fringing forest ..	.. 600
Fringing woodland ..	.. 300
Fringing scrub ..	.. 100
	1,000

(*d*) *The Luwegu-Mbarangandu system.* The Luwegu and Mbarangandu Rivers rise at an altitude of about 3,000 feet. The course of both rivers is

through *Brachystegia-Isoberlinia* woodland with fringing thicket until tropical rain forest is reached in the higher rainfall areas to the north.

The total length of the Luwegu-Mbarangandu system is 750 miles and the fringing vegetation types are estimated to be as follows :—

	miles
Fringing forest	100
Fringing woodland	500
Fringing scrub	150
	750

For the last 120 miles of its course from the confluence of the Great Ruaha and the Kilombero the Rufiji river traverses the tropical rain forest type but owing to low-lying ground which is subject to seasonal flooding there is little fringing forest and for up to a mile on either bank the vegetation is tall grass with scattered palms of *Borassus* and *Hyphæne*. About 25 miles from the sea the river splits up into numerous creeks to form the Rufiji Delta the tidal waters of which support mangrove forests extending over an area of about 300 square miles.

The total length of the Rufiji river system is estimated as follows :—

	miles
Njombe-Kizigo	700
Great and Little Ruaha	1,300
Ruhuji-Kilombero	1,000
Luwegu-Mbarangandu	750
Rufiji	120
Delta	130
	4,000

To summarise the above figures the fringing types are estimated to extend over the following distances throughout the course of the Rufiji river system :—

	miles
Forest and fringing forest	1,300
Fringing woodland	1,100
Fringing scrub	1,470
Mangroves	130
	4,000

6. *Matandu.* The Matandu rises in *Brachystegia-Isoberlinia* forest at 3,000 feet. Owing to its origin in the relatively dry savannah areas there is a great variation between the wet and dry season flow. In the savannah the banks are fringed with thicket but in higher rainfall areas in the Coastal belt gallery forest of the tropical rain forest type appears. Finally the tidal waters of the estuary are fringed with mangroves. The total length of the Matandu

including major tributaries is 450 miles, and types of fringing vegetation are estimated to cover the following distances :—

	miles
Fringing forest	70
Fringing woodland	370
Mangroves	10
	450

7. *Mbemkuru.* The Mbemkuru rises in *Brachystegia-Isoberlinia* forest at 2,000 feet. Like the Matandu there are great variations between the wet and dry season flow. The total length of the Mbemkuru including major tributaries is 500 miles and the different types of fringing vegetation are estimated to cover the following distances :—

	miles
Fringing forest	80
Fringing woodland	410
Mangroves	10
	500

8. *Lukuledi.* The Lukuledi rises in seasonal swamps in *Brachystegia-Isoberlinia* forest now being cleared for groundnut cultivation. The total length of the river is 100 miles but it is perennial only through the lower half of its course. Through the 50 miles of savannah the banks are fringed with thicket, frequently bamboo, in which *Pterocarpus zimmermannii*, *Cordyla africana*, *Tamarindus indica*, *Ficus* sp. In the higher rainfall areas of the coastal belt where the stream is permanent the type is tropical rain forest but owing to cultivation little fringing forest remain. The proportions of the various fringing types are estimated as follows :—

	miles
Fringing forest	20
Fringing woodland	50
Fringing scrub	25
Mangroves	5
	100

9. *Rovuma.* The Rovuma river, which, except for a distance of 30 miles east of Lake Nyasa, forms the boundary between Tanganyika and Portuguese East Africa, rises at an altitude of 3,000 feet on the eastern slopes of the range bordering Lake Nyasa. The Rovuma traverses savannah throughout the greater part of its course. In the lower reaches fringing thicket is displaced by trees of tropical rain forest species. Throughout the last 100 miles of its course the banks are well populated, seasonal flooding occurs, and the natural vegetation consists of grassland and scrub. The tidal waters of the estuary are bordered with mangroves. The total length of the Rovuma and its major tributaries is 1,770 miles and the fringing vegetation is apportioned as follows :—

	miles
Fringing woodland	1,600
Fringing scrub	150
Mangroves	20
	1,770

10. *Kagera.* The Kagera is the largest river flowing into Lake Victoria. It rises in Belgian territory and forms the boundary between Ruana and Tanganyika and for about 25 miles between Uganda and Tanganyika. The total length of the Kagera with its major tributaries is 600 miles. It rises in mountain grassland at 5,000 feet, and through a considerable part of its length traverses perennial swamp fringed with papyrus. For the last 50 miles of its course it passes through tropical rain forest extending for several miles on both banks where the ground is low-lying and the water table high. The vegetational types which it traverses are estimated to extend over the following distances :—

	miles
Fringing forest	70
Fringing woodland	150
Fringing scrub	150
Swamp	250
	620

Apart from the Kagera there are no permanent rivers entering Lake Victoria on the western shores and none in the south or east except the Mara river.

11. *The Mara* rises in temperate rain forest at 6,000 feet in the Kijarimweya Mountains in Kenya. Fringing forest up to ½ mile wide occurs throughout the greater part of its length. The commonest trees are *Ficus* sp. and *Markhamia platycalyx,* and *Podocarpus* occurs above 4,000 feet. The fringing forest comprises a dense undergrowth of shrubs and climbers including *Flacourtia* and *Grewia.* At the higher altitudes the surrounding vegetation is temperate rain forest and grassland giving place to *Acacia* savannah at lower levels. The total length of the Mara river including major tributaries is 500 miles and the various types of fringing vegetation are estimated to extend as follows :—

	miles
Fringing forest	500
Fringing woodland	50
Fringing scrub	150
	700

12. *Malagarasi.* The Malagarasi is the largest river flowing into Lake Tanganyika and with its tributary the Ugalla covers a drainage area extending north and south over a distance of 300 miles and east and west over 250 miles. The Malagarasi proper rises in the Urundi Highlands at an altitude of 6,000, feet and the flow is permanent. It is fed by the Moyowosi, Kikonga, Kigosi, and Igombe from the north and east which traverse *Brachystegia-Isoberlinia* woodland and *Acacia* savannah. The flow of these rivers is seasonal. The Ugalla river system comprising the Msima, Mkululu and Wala feeds the Malagarasi from the south and east. They also traverse dry savannah and the flow is seasonal though permament swamps occur. The banks of these water courses are fringed with thicket and although trees of *Tamarindus, Erythrophleum, Khaya,* and *Ficus* sp. are found neither the rainfall nor sub-soil water are sufficient to support tropical rain forest. The total length of the Malagarasi-Ugalla

river system is 2,800 miles and the types of fringing vegetation are estimated to cover the following distances :—

	miles
Fringing forest	100
Fringing woodland	2,500
Fringing scrub	100
Swamp	100
	2,800

13. *Sibiti.* The Sibiti, formed from the Manonga and Wembere river systems, flows into Lake Eyasi. The flow is seasonal but the rivers rise in permanent swamps in *Brachystegia-Isoberlinia* woodland and *Acacia* savannah. The country traversed by the Sibiti and its major tributaries has an altitude of 4,000—3,000 feet and a rainfall under 30 inches. True fringing forest does not occur but thicket is present where the banks are confined. Owing to the flat topography seasonal flooding is frequent and for a considerable width the water courses are bordered with a heavy black soil supporting an *Acacia* scrub vegetation. The total length of the Sibiti with its major tributaries the Manonga and the Wembere is 1,700 miles and the various types of fringing vegetation are estimated to cover the following distances :—

	miles
Fringing woodland	500
Fringing scrub	1,100
Swamp	100
	1,700

14. *Rungwa.* The Rungwa, which is joined by the Msaginia and the Kafufu rises in *Brachystegia-Isoberlinia* woodland at 4,000 feet and flows into Lake Rukwa. These rivers traverse a rainfall zone of 30–40 inches carrying *Brachystegia-Isoberlinia* woodland with *Acacia* savannah in the low-lying ground liable to flooding in the rainy season. The rivers are seasonal. The total length of the Rungwa system is 800 miles and fringing vegetation is estimated to cover the following distances :—

	miles
Fringing woodland	450
Fringing scrub	300
Swamp	50
	800

15. *Ruhuhu.* The Ruhuhu is the largest river from Tanganyika flowing into Lake Nyasa. It rises in mountain grassland, passes through temperate rain forest on the southern slopes of the Livingstone Range, and finally through long grass savannah before entering Lake Nyasa at 1,500 feet. The Ruhuhu proper is perennial but tributaries joining it from the savannah areas of lower rainfall to the east and south are seasonal. The total length of the Ruhuhu

with its major tributaries is 360 miles and the different types of fringing vegetation are estimated to cover the following distances :—

	miles
Fringing forest	100
Fringing woodland	200
Fringing scrub	60
	360

The following table gives a summary of the estimated distances in miles covered by the various types of fringing vegetation.

River	Fringing forest	Fringing woodland	Fringing scrub	Man-groves	Fresh water swamp	Total dis-tances
	miles	*miles*	*miles*	*miles*	*miles*	*miles*
Ruvu-Pangani ..	250	320	155	5	..	730
Umba	20	30	25	5	..	80
Wami	350	40	..	10	..	400
Ruvu	300	30	45	5	..	380
Rufiji	1,300	1,100	1,470	130	..	4,000
Matandu ..	70	370	..	10	..	450
Mbemkuru ..	80	410	..	10	..	500
Lukuledi ..	20	50	25	5	..	100
Rovuma ..	..	1,600	150	20	..	1,770
Kagera ..	70	150	150	..	230	600
Mara	300	50	150	..	..	500
Malagarasi ..	100	2,500	100	..	100	2,800
Sibiti	..	500	1,100	..	100	1,700
Rungwa ..	..	450	300	..	50	800
Ruhuhu ..	100	200	60	..	..	360
	2,960	7,800	3,730	200	480	15,170

"I have followed the classification into (i) Fringing forest, (ii) Fringing woodland, (iii) Fringing scrub as required but have added mangroves and fresh-water swamps. Mountain grassland and flood plain grassland have been included under 'Fringing scrub' but occurrence of these types had been indicated in the text. It may be of interest to mention that destruction of fringing forest for cultivation along the rivers of Tanganyika is negligible. The average density of population is 20 per square mile. The greatest concentrations of population are round the shores of Lake Victoria and on the southern slopes of Kilimanjaro and Meru. There has been little ribbon development along the banks of the rivers as might have been expected. For the most part they traverse uninhabited and sparsely populated country and the only destructive influence to which the fringing forests are subjected is attrition by fire particularly in the dry savannah zones".

The frequent mention of the *Brachystegia-Isoberlinia* woodland and *Acacia* savannah would appear to reproduce a type of savannah similar to that described around Jebba in

Central Nigeria and to the north as mentioned under Nigeria. In fact a type which on the same latitude spreads both east and west of Jebba. It would be interesting to know the area of country in Tanganyika occupied by this type of savannah—a type which could be saved from further degradation if put under the care of the Forester and not left to the destructive actions of the local population whether at present numerous in this type of area or not.

WEST AND EAST AFRICA

GENERAL NOTES ON THE RIVERS

As an introduction to this Section on West Africa, a list of the rivers from West Senegal to East Congo is given here, excluding the British Colonies.

We start with the French territory of Guinea in which the River Senegal rises.

1.	RIVER SENEGAL ..	(Territory of Senegal). Headwaters in French Guinea. Approximately 900 miles. Flows into the Atlantic Ocean. Fringing forest vegetation. Savannah 65 miles approximately Scrub 25 miles approximately. Approximately 10% of former tree vegetation.
2.	RIVER KASAMANGA ..	(French Guinea). Rises in mountains of French Guinea. Approximately 250 miles long, flowing into the Atlantic Ocean. Fringing forest vegetation ? Approximately ? of former tree vegetation.
3.	RIVER GRANDE ..	(Portuguese Guinea). Headwaters in French Guinea. Approximately 300 miles long, flowing into the Atlantic. Fringing forest vegetation ? Approximately ? % of former tree vegetation.
4.	RIVER COGON ..	(French Guinea). Headwaters in mountains of French Guinea. Approximately 250 miles long, flowing into the Atlantic.
5.	RIVER KUKURI ..	(French Guinea). Headwaters in mountains of French Guinea. Approximately 250 miles long, flowing into the Atlantic.
6.	RIVER ST. PAUL ..	(Liberia). Headwaters in mountain area. Approximately 350 miles long, flowing into the Atlantic.
7.	RIVER LESTOS NOON ..	(Liberia). Headwaters in mountain area. Approximately 250 miles long, flowing into the Atlantic.
8.	RIVER KAVALLI ..	(Liberia). Headwaters in mountain area. Approximately 250 miles long, flowing into the Atlantic.
9.	RIVER SASSNADRA ..	(Ivory Coast). Headwaters in northern mountains. Approximately 350 miles long, flowing into the Gulf of Guinea.
10.	RIVER KOMOE ..	(French Ivory Coast). Headwaters in northern mountains. Approximately 500 miles long, flowing into the Gulf of Guinea.
11.	RIVER BANDANA ..	(Ivory Coast). Headwaters in northern mountains. Approximately 400 miles long, flowing into the Gulf of Guinea.
12.	RIVER MONO ..	(Dahomey). Headwaters in the open savannah uplands of southern French Sudan. Approx. 300 miles long, flowing into the Gulf of Guinea.

13. RIVER OFE .. (Dahomey). Headwaters in open savannah in up lands of southern French Sudan. Approximately 400 miles long flowing into Gulf of Guinea.

14. RIVER NIGER .. (Nigeria). Headwaters in the Futa Jalon mountains of French Guinea and near Sierra Leone. Approximately 3,000 miles long, flowing into the Gulf of Guinea. Remaining tree and forest vegetation :

Mangrove	.. 10	miles approx.
Tropical Forest	.. 50	,, ,,
Savannah	.. 150	,, ,,
Scrub	.. 250	,, ,,

Approximately 15% of former tree and scrub vegetation.

15. RIVER SANAGA .. (French Cameroons). Headwaters in the Cameroons mountains. Approximately 500 miles long, flowing into the Gulf of Guinea.

16. RIVER MBAM .. (French Cameroons). Tributary of the River Sanaga. Headwaters in the Cameroons Mountains. Approximately 400 miles long, joining the River Sanaga.

17. RIVER OGOWE .. (French Gaboon). Headwaters in mountains of the French Middle Congo. Approximately 700 miles long, flowing into the Gulf of Guinea.

18. RIVER KUILU .. (French Gaboon). Headwaters in mountains of French Middle Congo. Approximately 400 miles long, flowing into the Gulf of Guinea.

19. RIVER CONGO .. (Belgian Congo). Headwaters in mountains of west of Lake Tanganyika. Approximately 3,000 miles long, flowing into the Atlantic Ocean.

20. RIVER UBANGI .. (Belgian Congo). Tributary of the River Congo. Headwaters in mountains to the west of Lake Albert. Approximately 1,200 miles long, flowing into the River Congo.

21. RIVER BOMU .. (Belgian Congo). Tributary of the River Ubangi. Headwaters in mountains in southern Sudan. Approximately 400 miles long, flowing into the River Ubangi.

22. RIVER ITURI .. (Belgian Congo). Tributary of the River Congo. Headwaters in mountains to the west of Lake Albert. Approximately 600 miles long, flowing into the River Congo.

23. RIVER IKENGE .. (Belgian Congo). Tributary of the River Congo. Headwaters in highlands of the middle Belgian Congo near Kinumbi. Approximately 500 miles long, flowing into the River Congo.

24. RIVER KASAI .. (Belgian Congo). Tributary of the River Congo. Headwaters in the area of north-east Angola. Approximately 900 miles long, flowing into the River Congo.

25. RIVER SANKURU .. (Belgian Congo). Tributary of the River Kasai. Headwaters in the mountain region of southern Belgian Congo. Approximately 800 miles long, flowing into the River Kasai.

26. RIVER KWANGO .. (Belgian Congo). Tributary of the River Kasai. Headwaters in the mountain region of northern Angola. Approximately 800 miles long, flowing into the River Kasai.

WEST AFRICA

SIERRA LEONE

Sierra Leone with its great natural harbour on a coast well known for a deficiency in this respect is one of the oldest of the British West African Colonies.

Doubtless much of the sea board Rain Forest which stretches from the coast 50 miles or so inland was felled and parts practically disafforested before the British arrived on the coast. Shifting cultivation has played a big part in reducing the agricultural quality and quantity of the savannah scrub or bush since then.

In reply to the questionnaire the Forest Department in the Colony said that no figures of value could be given regarding the fringing vegetation along the rivers.

> "Rivers in this country are useless from the forestry point of view. In the dry season they consist mostly of chains of rocky pools, and in the wet season they are swollen torrents. In consequence forest officers see little of them except at ferry crossing and fords. On the other hand an aerial survey of the country is in progress and should provide a very complete answer to your queries".

Personally, I am of opinion, that though for some purposes the æroplane can be a useful aid to the forester it will never enable the Forest Officer to obtain a real and, therefore, useful acquaintance with the growing stock on the ground or its real value as a good soil cover and, therefore, water conserver.

The remark that "In the dry season they (the rivers) consist mostly of chains of rocky pools and in the wet season they are swollen torrents" gives a very fair indication as to the condition of some at least of the catchment areas.

Mr. R. S. Pelly, now serving in the Colony, who had previous experience in British Honduras, and now home on leave (1949) has given some useful information based on practical knowledge (for he had no maps or files to consult)—

> "I had better start off by explaining that our information hardly is relevant to a world-wide, large-scale survey such as yours, as none of our rivers is more than about 250 miles long and, therefore, hardly shows in any ordinary map of Africa as a whole. However, I'll give you some notes for what they are worth. I shall forget all about tributaries, as the main rivers themselves are so small, and restrict the list to :
>
> 1. Great Searcies river (the boundary for some distance between Sierra Leone and French Guinea on the north. Length about 200–300 miles. Source mainly in mountain (2,000–3,000 ft.). Grasslands and savannahs which probably never were closed forest. Rises in, and flows through, country which is (and probably always was) sparsely inhabited. I doubt if the natural vegetation has been disturbed by man to the extent of more than 15–20% of the catchment area.
> 2. Rokel river. (Rises NE. Sierra Leone and flows SW. to join the sea at Freetown). Length 200–300 miles. Catchment more heavily forested than

those of the Searcies river, but probably more degraded by human influence. I don't suppose primeval closed forest represents more than 2–3% of the catchment area, but that is not to say that much of the catchment area is not covered with closed, secondary forest of varying age.

3. Mano river (boundary between Sierra Leone and Liberia and the South). Length about 200 miles. Fairly large areas of primary closed forest are left in the catchment (perhaps as much as 5–8% of the area) but the greater part has been subject to shifting cultivation at one time or another.

Grazing is an insignificant item in Sierra Leone—shifting cultivation has been responsible for the removal of the primary forest".

This last sentence is striking. To any forester with acquaintance with other colonies in West Africa it will be apparent that it is to the uncontrolled shifting cultivation of the past and present that the position and poverty in the soil and its food producing capacity is due. And that so much of the population on the countryside is ill nourished with diminishing hopes for any improvement as long as present habits survive.

LIBERIA

The Liberian Minister in London in reply to a request made in 1947 for some information on the subject of the forests in Liberia,—I gave a brief explanation of the types existing to the east of Liberia—wrote :—

"Professor Stebbing is quite right in his description of what he imagines the general forest aspect of Liberia is likely to be. The whole country is heavily wooded. Along the Coast there is a narrow belt, varying from 10 to 40 miles, which consists of farm land, second growth of forest and patches of tall forest. Beyond this is belt of dense primeval forest. The Country, though flat near the coast, gradually rises towards the interior, characterised by undulations and hill ridges. The dense forests are fringed by areas of cocoanut and oil palm trees, nearer the French (Ivory Coast) border there are large areas of kola nut trees.

"Across the middle part of the country are the so-called Gola forests which contain a great wealth of valuable hardwood. In the Lomar country and in parts of eastern Liberia, are similar smaller forests".

Mr. Lewis Smart, who had spent some years in Liberia in an Engineering capacity wrote (November 1947) as follows :—

"The rainfall in Liberia is heavy : 160″ to 180″ per annum, comparatively well distributed. The soil is good but there is a considerable proportion of swamps. Generally speaking the forests are, in my opinion, not secondary but mainly primeval, though there is quite a lot of shifting cultivation. There are no railways so the transport of logs to the coast, as in the Gold Coast, on a large scale, is not possible. Rafting logs to the coast needs more organisation than the Liberians can manage and those whom I have spoken to fear that if they did organise the industry the Government would deprive them of much of the profits.

"In 1945 of \$11,342,625 of exports, \$10,900,000 was plantation rubber which, for all practical purposes, means Firestone Plantations rubber".

On the subject of erosion, Mr. Smart writes to the Editor of the Royal African Society Journal :—

"I well remember Professor Stebbing, and the Soil Erosion Report he and his colleagues so ably prepared (1942, see p. 123)—and then we omitted it from our

Journal. It was I, who, at the Council Meeting over which Lord Athlone presided about 10 years ago, proposed this Soil Erosion Enquiry but our records do not show that. I had been pressing this Soil Erosion matter for years. I have seen over 2 feet of soil washed away in a single night, leaving below bare barren rock. Our support of the Soil Erosion enquiry was one of the best things the R.A.S. ever did, yet we did not include it in our Journal. Our then Secretary, Mr. Nicholson, deserved great credit for his work in the matter".

NIGERIA

The savannah and its origin has been alluded to under the Gold Coast. The following from notes made by myself in Nigeria reproduces the condition of affairs as I studied it in that great Colony.

Note made at Owo in the Ondo Province in the south-west of Nigeria in March 13, 1934 :

> A fine view of the country is obtained from the Rest House at Iwo—undulating country with distant hill ranges. The most distant ranges was hazy, but the intermediate one was seen to be intensively farmed—it appeared as a sea of forest, but with dark-topped tree crowns standing up at intervals from the bush, or so-called savannah, thus indicating only too clearly that they were the last remnants of the old mixed deciduous high forest. This is a common type of the existing country round here. "It would be difficult", says Mr. MacGregor, the Sylviculturist, "to find an area of high forest of sufficient size to form a reserve in this countryside".

This exemplifies the position in which the bush or savannah was held even by Forest Officers of the Colony—as if it had no importance either to the Forestry people or as important to the population itself who were so misusing it.

In the northern part of the Southern Province of Nigeria and in the southern parts of the northern territories, large areas of the so-called savannah forests are to be seen. The following note was recorded :—

> On leaving Lagos I went north to Kano in Northern Nigeria by train. I kept a note of the changing type of countryside during this journey.
>
> In Central Nigeria, about Ilorin, Jebba, etc., the same type of degraded mixed deciduous forest is to be seen as found more or less due west round Kintampo and Sampa in the Gold Coast and Bouake, Dabakala, Bondoukou in the Ivory Coast—so-called savannah whose true appellation is degraded mixed deciduous forest. In discussing the Kintampo region with Mr. Hemmant, Acting Governor of Nigeria, he himself drew my attention to Central Nigèria, saying that there was a large area of forest running for 100 miles or so to the north-east of Jebba of a similar type to that I was describing. That this area was more or less uninhabited, but fired annually by hunters. I could see little difference in this forest type, in which the genus *Isoberlinia* was characteristic, to the areas between Bouake and Bondoukou in the Ivory Coast and the forest to the east and south of Sampa.
>
> In Northern Nigeria I had inferred, from all that I had heard and read in reports that I should find a dry type of savannah forest—something like the savannah desert scrub one sees in the Punjab, Sind and Baluchistan in the north-west India.
>
> But much of the type of scrub which is now chiefly used for the pasturage of the large flocks and herds of animals—sheep, goats and cattle to be seen in this northern region—cannot be termed a true savannah type.

In fact, so far as my own observations went, it may be said that, save for areas in the vicinity of Geidam and a more general degradation of the forest areas in North Katsina, I saw little true savannah forest in Nigeria.

Kano in Northern Nigeria is a large town situated in the midst of a rich agricultural tract and is an important industrial centre of the north. Kano is considered to have a future before it—if not overwhelmed by the Sahara : and eventuality which, should the present methods of agriculture, grazing and firing of the forest lands continue on an increasing scale to the north, is more than a possibility within the next fifty years, or less.

Leaving Kano and proceeding due east to Damaturu and thence north to Geidam, three types of country are seen : (1) Farmed lands, with scattered baobab (*Adansonia*) and other species of tree, all carefully looked after ; the *Adansonia* trees are heavily pruned for their leaves. In the dry season it would be easy to mistake this type of country for savannah, with its dried grass areas and scattered scrub. This intensively cultivated country extends some 80 miles east of Kano, and is quoted as an example of the valuable type of agricultural areas existing in North Nigeria close to the desert to the north. (2) Considerable tracts of a dry degraded mixed deciduous forest of varying quality, subject to firing in the dry season by the natives, either for shooting purposes or for grazing. To this type of forest the term savannah has been misapplied. Much of it is capable of being restored to a fair quality high forest. (3) Lastly, the open more or less sandy areas covered with scattered thorn bush which are true savannah on the downward grade to pure desert.

For 80 miles east of Kano intensively cultivated lands are passed through. Then come 21 miles of dry zone, low bush or scrub forest with true savannah patches appearing at intervals to Jamaari. Between this place eastwards to Azare, Potiskum and Kamaturu, another 140 miles, the scrub or dry mixed deciduous forest (to give it its rightful name) predominates, interspersed with small 'farms'. The water encountered with the exception of wells, is found in the shape of longish meres or pools, appearing in unexpected places. I was told that it is held that these are probably the remains of old rivers, now reduced to these patches above ground. The explanation may be correct, since it is obvious that this country must have been formerly covered with a forest belt of a very different type to the scrub areas now existing.

The remains of the Great Bornu Forest, or Old Forest of Bornu, seen between Potiskum and Damaturu and between the latter and Geidam, is witness to the probability of this contention. This forest, open and scattered as it is, covered an area of 90 by 80 miles approximately, and is marked in part at least by the presence of old baobab trees.

The population in this region is extra-ordinarily dense for the type of country, due to influxes from the north ; and some change in the methods of agriculture and the treatment of the remaining forest areas would appear imperative if a further migration to the south is not enforced upon it. Up here the agricultural use of the forest is accompanied by the browsing and grazing of large herds of cattle and flocks of sheep and goats. Here again the numbers of animals are said to have greatly increased during the last two decades.

An examination of the forest soil displays a varying depth of pure sand on the surface, the Sahara averaging something under 100 miles distant from the Kano–Damaturu line.

We came upon a small local industry before reaching Damaturu—iron smelting in its original primitive form, as practised in Europe, e.g., Gaul and Britain, in Roman times. The fuel had for long been obtained from the surrounding 'bush', now become open and dwarf, with much sand present.

Geidam lies 90 miles to the north of Damaturu and under 20 miles from the French Niger colony and the Sahara ; before arriving there real evidence of the desert—sand invasion and true savannah thorn scrub with the typical Goriba or Dom palm (*Hyphœne thebaica*)—began to appear. This palm branches like a candelabra.

Here on this frontier of the desert the people are more interested in cattle than in agriculture—a point which had by now become predominant one in my investigations.

Geidam used to be the headquarters of the District Officer and some troops were quartered here. Both have been moved further south. It is curious to realise up here in this region on the edge of the Sahara that the population is actually increasing whilst the means of supporting it are obviously and visibly decreasing.

When Geidam was the headquarters of the District Officer the area around the headquarters house included a small portion of forest. This has been left untouched, even after the transfer of the Government Officers, as it was regarded as Government land. It now forms a valuable object lesson, as it shows what the forest was like twenty years ago as depicted in the photograph. Twenty years ago, when Mr. de Putron joined Geidam as an Assistant Political Officer, on first appointment, all the country round Geidam was, he says, under forest of the height and type shown in the District Officer's plot now remaining.

The curious thing about this part of Nigeria is that a river, the Komadugu Yobe, runs due east and west about a mile or so from Geidam, with good duck-shooting. An inspection showed that the river at the end of the hot-weather season consisted of a series of large interrupted pools, the major part of the water flowing underground. On going due west to Nguru from Geidam (147 miles) the river is followed closely by the cold-weather road as far as Jawa. This river is said to be the collection of all the rivers, or bits of rivers, passed to the south between Kano and Damaturu, and it flows into Lake Chad to the north-east of Geidam. As has been said up here, it has offsets or meres at this time of the year. In the rainy season it apparently floods all this part of the country, closing the cold-weather road.

The interesting thing about the river is that even up here, so close to the desert, it is lined with what is so aptly termed in West Africa, Fringing forest, locally called Kurumis ; of a good mixed moist deciduous type. The species in this fringing forest are far north of their normal habitat. It is a curious sight to see this beautiful green high forest running as a narrow belt across the country, clothing each bank of the river, and to contrast it with the desert-like savannah forest stretching away on either side to the north and south, with the yellow sand of the outer borders of the desert showing here and there as low sandhills away to the north.

The Rivers in Nigeria :

The main rivers of Nigeria in their order of importance are as follows :—

1. RIVER NIGER .. (In Nigerian territory. Total length given under West Africa).
   In Nigeria, approximately 750 miles, flowing into the Gulf of Guinea.

Fringing forest vegetation (in linear miles) :

Mangrove	10	miles approximately
Swamp forest / Rain forest	40	,, ,,
Savannah	25	,, ,,

Approximately 10% remaining of the former fringing forest vegetation.

2. **RIVER BENUE** .. (In Nigerian territory).

Approximately 475 miles. A tributary of the River Niger. Headwaters in the Cameroons region.

Fringing forest vegetation 100 miles approximately. Approximately 21% of the former forest vegetation. Headwaters in the scattered savannah vegetation of the northern Cameroon mountains area.

3. **RIVER CROSS** .. Approximately 250 miles. Headwaters in the Cameroon mountains. Flows into the Gulf of Guinea. Fringing forest vegetation :

Mangrove ..	5	miles approximately
Swamp forest ..	20	,, ,,
Rain forest ..	30	,, ,,
Savannah ..	25	,, ,,

Approximately 30% remaining of former fringing forest vegetation.

4. **RIVER OGUN** .. Approximately 200 miles. Headwaters in scattered savannah woodland.

Fringing forest vegetation :

Swamp forest ..	15	miles approximately
Rain forest ..	15	,, ,,
Savannah ..	60	,, ,,

Approximately 45% remaining, as parts of the river flow through forest reserves.

5. **BENIN RIVER** .. Approximately 100 miles long. Headwaters in Benin region—formerly Tropical Rain Forest. Flows into the creeks of the Benin-Warri region—thence to Gulf of Guinea.

Fringing forest vegetation :

Mangrove ..	5	miles approximately
Rain forest ..	40	,, ,,

Approximately 45% of former forest vegetation, as part flows through forest reserves.

6. RIVER SHASHA .. Approximately 75 miles long. Headwaters in the forest area of western Oyo Province. Flows into the Ijebu-Ode Creek area and thence to Gulf of Guinea.

Fringing forest vegetation :

Mangrove	..	5 miles approximately.
Swamp forest	..	20 ,, ,,
Rain forest	..	40 ,, ,,

Approximately 86% of forest vegetation remaining, as part flows through forest reserves.

7. RIVER KATSINA ALA .. Approximately 150 miles. Headwaters in open savannah woodland on western slopes of the Cameroon mountains.

Fringing forest vegetation :

Savannah 30 miles approximately.

Approximately 20% of former tree vegetation remaining.

8. RIVER TEMBA .. Approximately 150 miles. Headwaters in open savannah woodland.

Fringing tree vegetation :

Savannah 30 miles approximately.

Approximately 20% of former tree vegetation remaining.

9. RIVER GONGOLA .. Approximately 300 miles long. Rises in foot-hills of the Jos Plateau in savannah. A tributary of the River Niger.

Fringing tree vegetation 30 miles approximately.

Approximately 10% of the former tree vegetation.

10. RIVER KADUNA .. Approximately 300 miles long. Rises near Jos on the Jos Plateau in grassland. A tributary of the River Niger. Fringing tree vegetation 30 miles approximately.

Approximately 10% of the former tree vegetation.

11. RIVER SOKOTO .. Approximately 400 miles long. Rising in savannah in SE. Sokoto Province. A tributary of the River Niger. Fringing tree vegetation approximately 20 miles.

Approximately 5% of the former tree vegetation.

12. RIVER HADEJIA .. Approximately 400 miles long. Rising in farmland in SW. Kano Province. Flowing into the River Komadugu Yobe, thence into Lake Chad.

Fringing tree vegetation approximately 10 miles.

Approximately 2·5% of the former tree vegetation.

13. RIVER KOMADUGU YOBE Approximately 400 miles long. Rising in scattered savannah near Bauchi. Flowing north-eastwards into Lake Chad.

Fringing tree vegetation approximately 20 miles.

Approximately 5% of the former tree vegetation.

14. RIVER JIBIYA .. Approximately 125 miles long. Rising near Ruma in Western Katsina Province. A tributary of the River Sokoto which flows into the Niger.

Fringing tree vegetation approximately 25 miles.

Approximately 20% of former tree vegetation as part of the river flows through a forest reserve.

GOLD COAST

The following extract from the late Dr. T. F. Chipp's "The Gold Coast Forest" (1927)—

"Comparatively no botanical or forestry survey work has so far been carried out in this country on the vegetation of the Soudanese Zone, and consequently it is not possible at the present stage to define the limits of the sub-divisions into Savannah forest and Savannah. The controlling factor over this zone, apart from its proximity to the more arid conditions of the north, is the annual grass fires, which, sweeping over extensive areas of country for many decades, must now be considered in the light of a natural factor. Strips of the original closed forest are still found in its southern edges along water-courses and on the south side of the hill masses. Beyond that savannah forest and savannah stretch away to the north, the forest patches or isolated trees ever becoming fewer.

"In the west all the country north of 7° 30′ belongs to this savannah zone. As one proceeds eastwards the limits bear towards the south, but keep to the north of the Mampong, Agogo, Kwaku and Akwapim ranges of hills. In the east of the colony it has supplanted the Guinea vegetation right down to the sea front. It is now steadily progressing along the sea front in the shape of a wedge, ever widening behind, and at the same time extending its thin edge westwards. In this manner it has progressed as far as Sekondi. Westwards of Sekondi it cannot yet be said to be established, although many of its characteristic denizens, such as *Borassus*, *Phœnix*, and *Sauseveria*, are found as far as Half Assinie along the sea front, and the latter two right to the western frontier of the colony. The extension of corn and groundnut farms between Sekondi and Half Assinie is causing the tall forests to contract inland rapidly and so preparing for the conversion of this country to the Soudanese vegetation".

On this I remarked in my book "The Forests of West Africa and the Sahara" (1937)—

"This is the recorded opinion of a distinguished forest botanist or ecologist. Scientifically there can be no question of its interest. From the practical forester's point of view, and that of the District Officer, there are dangerous assumptions: e.g., that the annual forest fires 'must now be considered in the light of a natural factor'. Botanically, perhaps. But the ultimate result is to produce a desert. The acceptance of degraded mixed deciduous forest as savannah is equally misleading".

In these West African parts between the Sahara and the Sea coast the species in the form of fringing forest often run far out of thier actual present day habitat. In other parts species of the rain forest will be found in the moist deciduous and of the latter in the dry deciduous, in the belt of forest clinging to the river where on the countryside there is nothing left but savannah becoming more and more degenerate as it moved northwards to the south side of the Sahara, where thorny thickets supervene.

I have seen fringing forest clinging to the river edge on rivers close to the southern edge of the Sahara. It is in connection with this type of forest that the following information

on the rivers of the Gold Coast is given by Mr. C. J. Taylor. *Fringing forest.* The following rivers with length of fringing forest along them are given for the Gold Coast :—

River	Length (in miles)	Fringing forest (in miles)	Fringing woodland (in miles)	Fringing scrub (in miles)
Black Volta	400	300	100	..
White Volta	330	..	330	..
Oti	320	..	320	..
Volta	310	70	130	..
Tano	250	..	..	..
Daka	220	..	220	..
Afram	180	60	120	..
Pra	160	..	..	..
Ofin	150	..	..	..
Kulpawn	140	..	140	..
Ankobra	130	..	..	..
Pru	120	30	60	..
Birim	110	..	..	..
Sene	110	40	70	..
Bia	100	..	..	..
Tain	100	30	10	..
Sibili	90	..	90	..
Obosum	80	..	80	..
Densu	70	..	..	30
Nasia	70	..	70	..
Red Volta	40	..	40	..
	3,480	530	1,780	30

" As you will realise, these are only rough approximations.

" My interpretations of Dr. Fairbairn's terms for riverside forest vegetation outside the high forest are :—

(*a*) Fringing forest—in savannah woodland, not far removed from high forest, and very similar to the latter.

(*b*) Fringing woodland—deeper into savannah woodland and where the species are those of the savannah, but the stocking is denser and the trees are bigger. Some of the species grow only where these better conditions of moisture are found.

(*c*) Fringing scrub—found in very open savannah woodland where the riverside vegetation is scrub".

(*To be continued*)

INDIGENOUS CELLULOSIC RAW-MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART II.—PULPS FOR WRITING AND PRINTING PAPERS FROM THE CASTOR OIL PLANT (*RICINUS COMMUNIS*)

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INTRODUCTION

Bamboo and sabai grass (*Eulaliopsis binata*) are the chief cellulosic raw-materials used in the paper industry in our country. The locally available supplies of these raw-materials are not adequate to meet the pulping capacity of the existing paper mills. The production of paper in our paper mills was 1,03,195 tons in 1949 and the domestic consumption of all varieties of papers (excluding newsprint) was about 1,70,000 tons in that year. To meet the domestic demand for paper, a large quantity has to be imported every year. It is estimated that the consumption of paper in our country will increase to about 2,00,000 tons over the next five years. In order to be self-sufficient in paper, we will have to produce more and more paper. This can be done by increasing the capacity of the existing uneconomic units and by installing new plants. For both these purposes additional quantities of raw-materials will be required.

Availability of bamboo and sabai grass for the production of paper is limited because the former is used for a large variety of purposes and the latter grows only in particular areas. Recently the prices of these raw-materials have gone up very considerably. One of the chief considerations that govern the choice of a suitable raw-material for the paper industry is its availability in large quantities on a sustained yield basis at a cheap price. Waste materials having no other uses are ideal raw-materials for the production of paper. The stem of the castor oil plant is one such material.

Reimold[1] advocated the cultivation of the castor oil plant in America as a high grade cellulose could be produced at a low price because of the cheapness of the raw-material. In their investigations on the production of sulphate pulps from various annual plants, Jayme and coworkers[2] found that pulps from castor stalks had a very high folding endurance. These authors also prepared pulps of good strength properties from castor plant roots. Nazir Ahmed and Karnik[3] found that pulps from castor stalks were characterized by high alpha-cellulose contents. Champer[4] took a patent for the production of a thermosetting resin from a reaction product of a phenol and cellulose prepared from castor stalk by treatment with nitric acid solution of 0·16 to 0·5 N for a period of 3 hours. According to Floyd[5] the bark of the castor plant has no value as a material for pulp but the debarked and defibred chips prepared by the sulphate or the nitric-sulphuric acid method give a paper, which, while not as strong as paper from pine wood, can be used for book paper and as a substitute for pine pulp for several purposes. Oku and Takigawa[6] prepared bleached pulp with good strength from the bast of the castor oil plant.

The castor oil plant is grown in several parts of this country as an annual crop for its seeds which are used for obtaining castor oil. The Indian Central Oil Seeds Committee of the Ministry of Agriculture, Government of India, suggested the testing of castor stalks of the annual variety for the production of paper. Since the castor oil plant is also grown as a perennial tree, investigations were also undertaken on the production of easy bleaching pulp from this variety also. The results of these investigations carried out at the Forest Research Institute, Dehra Dun, are recorded in this leaflet as an interim report.

CULTIVATION AND USES

The castor oil plant (*Ricinus communis*, Linn.) belongs to the Natural Order Euphorbiaceæ. It is known as *arend* in Hindi. It grows as a large shrub or a small tree with thin light greyish brown bark. Its wood is white, soft and light with large central pith and occasionally an irregular brown heartwood[7]. It is a plant of the tropics and is probably indigenous to Africa[8]. It is cultivated throughout India. It often grows wild in places far from and near habitations. Its botanical description is given by Brandis[9].

Mainly two types of castor oil plant are grown[10]. One is a small tree of perennial growth usually planted as a hedge or in lines through the fields where it affords desirable shade to other and more valuable crops. The other is an annual plant grown as a crop for castor seeds for the production of oil. The castor oil plant ascends the Indian hills to an altitude of 6,000 feet. It prefers well-drained loams ; loose sandy or heavy clay soils are unsuitable. It grows best in free working soils. It is not likely to be a profitable crop on rich soils. Its cultivation is, therefore, recommended only on borders of fields or on such lands as cannot be profitably utilized for raising common crop.

Two to three ploughings are enough for sowing castor seeds. Farm-yard manure at the rate of 10–15 cart loads per acre may be applied with advantage, particularly in the case of the perennial variety[11].

The crop is sown in July and August and is ready for harvest in March and April. After the harvesting season is over and all the seeds are removed, the stems of the annual variety are allowed to dry in the field till they are cut by the cultivator for burning. The perennial variety gives a fair crop for five to six years under favourable conditions but maximum yields are usually obtained in the second or third year after sowing.

The perennial variety gives a large seed with an abundance of oil of an inferior quality, which is generally used as a lubricant and for illuminating purposes. The annual plant gives small seeds which yield oil of a superior quality, which is used for medicinal purposes[8]. Castor oil is also used in paint, leather and textile industries. The castor plant is cultivated in Assam and adjoining regions for its leaves on which are fed the *Eri* silk-worms.

AVAILABILITY

The total acreage under castor crop in various States in this country, the yield of stalks per acre and the total quantity of stalks in those States are given in Table I. These figures relate to the year 1950 and were supplied by the Secretary, Indian Central Oil Seeds Committee, New Delhi.

TABLE I

States	Total acreage under crop in thousand acres	Yield of stalks per acre in maunds	Total quantity of stalks in thousand maunds
1. Bihar (excluding merged territories) ..	17	10	170
2. Bombay ..	102	7	714
3. Madhya Pradesh ..	33	10	330
4. Madras ..	225	30	6750
5. Orissa ..	47	10	470
6. Uttar Pradesh ..	9	35	315
7. Hyderabad ..	823	30	24690
8. Madhya Bharat ..	5	10	50
9. Mysore ..	89	30	2670
10. Saurashtra ..	40	7	280
11. Vindhya Pradesh ..	1	7	7

THE RAW-MATERIAL

Castor stems of the annual as well as perennial variety were used for the experiments. The castor stalks of the annual variety used in the initial experiments were supplied by the Economic Botanist, Himayat Sagar Farm, Hyderabad (Deccan). These stalks varied in length from 4 feet to 6 feet and in diameter from ½ inch to 1¼ inches. As these were stocked in the open near the laboratory, they were exposed to rain for a long period and consequently they developed a dark colour. Since the high bleach consumption of their pulp was presumed to be due to this exposure, fresh experiments were carried out on the annual variety of castor stalks growing wild in the Forest Research Institute Estate. These stalks varied in length from 6 feet to 8 feet and in diameter from ½ inch to 1½ inches. The thin bark of the main stems was of dirty white colour while that of the shoots was maroon. The woody portion of the stalks was yellowish white in colour.

Experiments were also carried out on the perennial variety of the castor plant. Some stems of this were obtained from Sister Mirabehn's Ashram, Pashulok, at Rishikesh and some were supplied by the Land Management Officer, Forest Park, Etawah (U.P.). The stems received from Rishikesh were about 8 inches in length and about 4 inches in diameter. The colour of the thin bark was grey while that of the wood was yellowish white. The material from Etawah consisted of billets of varying lengths and diameters. The wood was of light cream colour.

The bark was removed only in the case of the perennial variety obtained from Rishikesh. In all other cases the stems were used for the experiments with the bark. The castor stalks of the annual variety with the bark were crushed in the factory crusher and then cut into chips of about 1 inch in length. The stems of the perennial variety were cut into chips of about 1 inch in length without prior crushing. Fines were rejected by sieving the chipped material on 20 mesh sieve. This chipped and sieved material was used for these investigations.

CHEMICAL ANALYSIS

In order to get an idea of the cellulose content and other constituents of the castor stems the material without the removal of the bark was analysed by the standard Forest Products Laboratory methods[12] except in the case of the estimation of pentosans where the TAPPI standard T 223 m-48 was employed. Both the annual variety from the Forest Research Institute Estate and the perennial variety from Etawah were chemically analysed in order to find out the differences in their constituents. About 250 grams of the chips were converted into dust by disintegration in a laboratory disintegrator and the material passing through 60 mesh and held over 80 mesh was used for the analysis. Results of the chemical analysis of the two varieties of the castor stems are given in Table II.

TABLE II

Chemical Analysis of Castor Stems (Ricinus communis)

Property	Annual variety % on the oven-dry basis except moisture	Perennial variety % on the oven-dry basis except moisture
1. Moisture ..	7·03	9·70
2. Ash ..	2·84	2·98
3. Cold water solubility ..	13·55	9·57
4. Hot water solubility ..	13·70	9·90
5. 1% NaOH solubility ..	30·87	30·38
6. 10% KOH solubility ..	40·85	40·50
7. Ether solubility ..	1·56	1·28
8. Alcohol-benzene solubility ..	5·34	6·12
9. Pentosans ..	16·19	16·99
10. Lignin ..	19·30	19·79
11. Cellulose (Cross and Bevan) ..	51·60	51·19

From these results it is seen that there is no appreciable difference between the annual and perennial varieties as far as their various constituents are concerned. The cellulose content of the castor stems is not as high as that of bamboo (59–62% cellulose) or sabai grass (54–57% cellulose) but is sufficiently high to warrant its utilization for the production of paper. Compared to bamboo (24–28% lignin) its lignin content is low.

FIBRE LENGTH

In order to determine the length of the fibres of the pulp from castor stems, the crushed and chipped material (annual variety) free from the bark was digested with caustic soda under pressure. The material was washed free from alkali and bleached. The bleached pulp was diluted with water and stirred by means of a small stirrer rotated by an electric motor till the fibres were separated. A small portion of the pulp was taken on a watch glass, diluted and used for making slides. Each slide contained about 10 fibres in each field. Herzberg stain was used for staining the fibres. For determining the fibre length, only unbroken fibres were measured. Two hundred fibres were measured for the determination of the fibre length. In a similar way fibre length was measured in the case of the bleached pulp prepared from the bark of the castor stalk. The fibre length of the pulp from the perennial variety of the castor

plant was also measured in order to compare with that from the annual variety. The results of the measurements are given in Table III.

TABLE III

Fibre Length

		Annual variety		Perennial variety
		Stem without bark	Bark	Stem without bark
Fibre length	Minimum	0·50 m.m.	3·47 m.m.	0·60 m.m.
	Maximum	0·94 m.m.	9·29 m.m.	1·12 m.m.
	Average	0·81 m.m.	5·48 m.m.	0·86 m.m.

From these results it is seen that the average fibre length of pulps from the stems of the annual variety is nearly the same as that of the perennial variety. The pulps from the stems of these varieties, however, are short-fibred, but their barks yield long fibred pulps.

PRODUCTION OF PULP

A number of digestions were carried out using the sulphate and the soda processes. In the sulphate process a mixture of caustic soda and sodium sulphide in the ratio of 2 : 1 by weight was used. In the soda process caustic soda alone was used. In the first series of experiments the castor stalks obtained from Hyderabad were used. The digestions were carried out by the sulphate process. The conditions of digestions, pulp yields, bleach consumption and strength properties of standard sheets are given in Table IV.—(*See pages* 456–457).

The high bleach consumption of pulps from these stalks was presumed to be due to the dark colour they developed on exposure to rain for a long period. Hence fresh stalks from the castor oil plant growing wild in the Forest Research Institute Estate were next digested under various conditions by the sulphate and the soda processes. The digestion by the soda process with even 24% alkali at 153°C for 6 hours yielded undercooked pulps. The results of the experiments by the sulphate process are given in Table V and those by the soda process in Table VI.—(*See pages* 460–461).

Digestions of the perennial variety of the castor oil plant were carried out by the sulphate process. One digestion was carried out on the stems after the removal of the bark in order to find out whether this offered any special advantage. The results of the experiments on the perennial variety of the castor oil plant are given in Table VII.—(*See pages* 462–463).

DISCUSSION

On camparing the digestion conditions given in Tables IV and V it is seen that the castor stalk which was exposed to the rain for a long period and which had consequently developed a dark colour gave well-cooked pulps under milder conditions than the fresh stalks but the bleach consumption of their pulps was uneconomically high. This was due to the decay that set in on exposure to the rain for a long period during storage in the open. So the results given in Table IV cannot be taken to hold true in the case of castor stalks which are stored properly. These results indicate that care must be taken in storing castor stalks meant for the production of pulp.

Results given in Tables V and VI show that easy bleaching pulps can be obtained in satisfactory yields from castor stalks of the annual variety by digesting these under suitable conditions by the sulphate and the soda processes. Easy bleaching pulps are obtained under milder conditions by the sulphate process than by the soda process. The strength properties of the pulps by both the processes are quite satisfactory for the production of writing and printing papers. The folding endurance of pulps by the sulphate process is considerably higher than that of the soda pulp.

Results given in Table VII show that easy bleaching pulps with satisfactory strength properties can be prepared by the sulphate process from the castor oil plant of the perennial variety. The bleach consumption is less when the wood is used without the bark. Debarked wood of this species can be digested under milder conditions than when the bark is not removed. There is no appreciable difference in the strength properties of pulps from castor wood with and without the bark.

Since the castor oil plant crop is grown for seeds which are used for extracting oil, and there is no special use for the stalks, the stalks should be available at a very cheap rate. From Table I it will be seen that large quantities of castor stalks are available annually in Madras, Hyderabad, Mysore, Orissa, Bombay and Uttar Pradesh. Paper mills in these areas can utilize the castor stalks for pulping and the pulp obtained can be used for admixing with long fibred pulps from bamboo or sabai grass for the production of writing and printing papers. Since the pulps from the stalks are short fibred, pilot plant experiments will be carried out to find out whether these pulps can be used for the production of writing and printing papers or these must be mixed with long fibred pulps for this purpose.

If the castor plantations of the perennial variety are worked on a five-year rotation with a complete series of age gradations, the seeds will be available every year for the extraction of oil and the wood for the production of pulp. The cost of collection may also be less. Another advantage is that the tree will attain a sufficient girth in five years to be suitable for grinding on mechanical grinders for the production of groundwood pulp for newsprint. Since the wood of this species is nearly white, experiments have been undertaken in this laboratory for the production of mechanical pulp for newsprint.

CONCLUSIONS

1. Easy bleaching pulps with satisfactory strength properties can be prepared from stems of castor oil plant by the soda and the sulphate processes. The sulphate process is more suitable than the soda process for the production of these pulps.

2. The stems of the annual and the perennial varieties can be used for pulping without the removal of the bark.

3. The pulps from the wood are short-fibred whereas those from the bark are long-fibred. As the pulps from the woody portion are short-fibred, pilot plant experiments will have to be carried to determine whether these pulps can be used as such for the production of writing and printing papers or these must be mixed with long-fibred pulps such as those from bamboo or sabai grass.

4. Since the castor crop is grown for the seeds, the stalks should be available at a cheap rate and should provide a cheap raw-material for the production of writing and printing papers.

Thanks are given to the Indian Central Oilseeds Committee, New Delhi, for suggesting this problem and for supplying the castor stalk as well as information regarding the growth characteristics, availability, etc., of castor stalks. Thanks are also due to Sister Mirabehn, Pashulok Ashram, Rishikesh and the Land Management Officer, Forest Park, Etawah, for the supply of castor wood of the perennial variety.

TABLE IV—*Sulphate digestions of castor stalks received from*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching* powder	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	20	4	162° for ½ hour and 148° for the remaining period	4	19·7	44·1	17·14	36·9
2	20	4	162° for 1 hour and 148° for the remaining period	4	19·7	46·0	16·90	36·8
3	20	4	153°	4	19·9	45·1	15·80	41·6
4	24	5	153°	4	20·2	42·3	15·00	38·9

* The % is expressed on the basis of the raw-material (air-dry).

Hyderabad and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metres	metres	%				
161	61·1	7420	6·4	67·2	48·2	1330	A few shives. Hard bleached.
219	60·5	5667	5·1	76·3	40·4	1530	In this and Serial Nos. 3–4 well cooked pulps were obtained but the bleach consumption was very high.
198	59·4	6910	5·0	70·0	48·5	1070	
167	62·2	5571	5·1	84·0	42·1	1150	

TABLE V—*Sulphate digestions of castor stalks from the*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching* powder	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	22	4	162° for 1 hour and 153° for the remaining period	4	19·83	49·6	15·78	44·4
2	22	4	162° for 3 hours & 153° for the remaining period	6	19·7	44·6	6·51	41·3
3	22	4	162°	6	20·8	44·3	6·04	40·8
4*a*	24	4	162° for 1 hour and 153° for the remaining period	4	21·5	46·6	6·42	40·0
b	,,	,,	,,	,,	,,	,,	,,	,,
5*a*	24	4	162° for 1 hour and 153° for the remaining period	6	22·79	46·6	6·02	39·94
b	,,	,,	,,	,,	,,	,,	,,	,,
6	24	4	162° for 2 hours & 153° for the remaining period	4	20·8	44·7	5·62	37·7

* The % is expressed on the basis of the raw-material (air-dry).

Forest Research Institute Estate and strength properties of the standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metres	metres	%				
180	60·8	8337	3·3	90·4	60·8	1960	Good cook, very few shives present. Hard bleached.
263	53·8	8400	3·5	68·3	52·6	2150	In this and Serial Nos. 3–6 well cooked and easy bleaching pulps were obtained.
263	60·1	7244	3·2	60·7	43·7	1550	
293	59·3	8727	3·3	76·0	52·5	1040	
195	61·3	8680	2·8	66·4	57·1	1190	
271	51·3	8972	2·7	70·6	51·1	1360	
190	61·4	8718	3·0	67·8	51·7	1500	
270	57·0	7096	3·4	58·3	37·2	780	

TABLE VI—*Soda digestions of castor stalks from the*

DIGESTION CONDITIONS AND PULP YIELDS								
1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	24	4	162° for 3 hours & 153° for the remaining period	6	21·4	43·0	6·45	37·0
2	24	4	162°	4	20·3	45·3	6·85	38·5
3*a*	24	4	162°	6	21·1	43·7	6·53	39·4
b	,,	,,	,,	,,	,,	,,	,,	,,

* The % is expressed on the basis of the raw-material (air-dry).

Forest Research Institute Estate and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F							
10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metres	metres	%				
200	62·1	7191	2·8	67·2	39·2	350	In this and Serial Nos. 2 and 3 well cooked and easy bleaching pulps were obtained.
220	59·7	8822	3·0	64·5	39·6	450	
307	63·0	7787	3·0	65·0	44·4	750	
200	62·4	8699	2·6	57·5	46·5	490	

TABLE VII—*Sulphate digestions of castor wood* (perennial)

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total Alkali as NaOH*	Concentration of alikali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	22	4	162°	6	21·1	44·0	6·39	41·4
2	24	4	162° for 2 hours & 153° for the remaining period	4	19·7	43·0	6·03	38·1
3	24	4	162° for 1½ hours & 153° for the remaining period	6	22·1	43·4	5·85	38·0
4	24	4	162° for 1 hour & 153° for the remaining period	5	21·6	45·2	5·36	39·5
5	22	4	162°	4	19·5	46·1	4·52	43·5
6	22	4	162°	4	21·2	45·1	4·72	42·2

* The % is expressed on the basis of the raw-material (air-dry).

and strength properties of standard sheets

Strength Properties of Standard Sheets Conditioned at 65% R.H. and 70°F							
10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Mullen)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metres	metres	%				
284	60·0	8309	3·5	71·6	46·6	990	Wood was received from Etawah. Digestion was done without removal of the bark.
284	60·5	8915	3·2	66·1	49·7	920	Wood was received from Etawah. Digestion was done without removal of the bark.
305	61·0	8360	3·3	66·4	52·4	1410	Wood was received from Etawah. Digestion was done without removal of the bark.
290	60·0	8352	2·1	85·5	47·1	1600	Wood was received from Etawah. Digestion was done without removal of the bark.
330	60·8	8422	2·8	68·3	49·2	1120	Wood was received from Etawah. Used without bark.
300	62·8	8629	2·8	78·8	61·6	1900	Wood was received from Rishikesh. Used without bark.

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COLOURATION OF HYDROGENATED FATS WITH CHLOROPHYLL TO PREVENT ADULTERATION OF GHEE*

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During the last few years hydrogenated fats, popularly known as "Vanaspati" or vegetable ghee, have become an important item of human diet in this country, the annual production during the year 1949 being as much as 1,55,000 tons[1]. At the same time it has become a handy and cheap adulterant of ghee. To prevent such an abuse of vanaspati it has become necessary to colour it suitably so that its presence, if used as an adulterant, can be readily detected by the buying public. The choice of the colouring matter depends on several important considerations :—

(1) it should be an edible dye which does not have any cumulative harmful effect on the human system ;

(2) it should impart a pleasing colour ;

(3) it should be easily available at a reasonable cost and in large quantities ; and

(4) it should not get easily decolourized on simple physical treatments like exposure to sunlight or heating and if possible even on treatment with animal charcoal and Fuller's earth.

It is no doubt difficult to secure such a dye because most of the edible dyes undergo decolourization or discolouration on exposure to sunlight or on heating and are also absorbed either completely or partially by animal charcoal and Fuller's earth. In spite of the limitations indicated above, it may, however, be possible to fix upon a suitable vegetable colouring matter which very nearly satisfies the prescribed conditions. In this connection it might be pointed out that a number of vegetable colouring matters have already been tried, namely, turmeric, paprika, kamala[2], annatto[2], ratanjot[3], etc. Turmeric imparts a pleasant lemon-yellow colour to the fat and its presence can also be easily detected with lime water or boric acid test. The difficulty, however, is that slightly adulterated samples of ghee have a pale yellow colour similar to that of cow ghee and can be passed off as pure ghee itself. Paprika dye is not a convenient one for the main reason that the raw material is costly and is needed for other edible purposes. Further, the dye gets decolourized under conditions of exposure to light and heat. Kamala, no doubt, gives a beautiful orange red colour which is quite distinct. However, it is stated that for proper detection of adulteration, the hydrogenated fat must be coloured with as much as even 4% of kamala, and objections have been raised in some quarters that in such concentrations the dyestuff is likely to have some cumulative deleterious effect on the human system. Annatto dye in low concentrations gives a yellow colour to the fat but in higher concentrations the colour is orange like that of kamala. It is a pleasant food colour but is not available in sufficient quantity in the country. The main objection to the use of ratanjot is that sufficient quantities are not available in the country.

Experiments carried out in this laboratory have shown that chlorophyll can be successfully used for the colouration of hydrogenated fats. It occurs in the green leaves of both agricultural and forest plants and is available in any quantity. It is edible and is not reported to have harmful cumulative effects on the human system. On the other hand it is stated to act as

* A preliminary note on the subject has already been published in Current Science, 1951, **20**, 68.

an oxidation catalyst in the human metabolic processes[4]. Thus it is said "It is the most powerful catalyst in the world if administered either orally or intravenously to human beings and will act as oxidation catalyst in metabolic processes of the human body. This is of utmost importance especially for aging organisms, since pathological changes such as arterio-sclerosis, diabetes, obesity, etc., are due to the slowing down of the rate of oxidation in the cell. Chlorophyll, the life giving substance is probably the answer to the prayer for prolonging the useful span of life". Further, it has been recently discovered that chlorophyll has an ability to act as a body-and breath-deo dorant, on oral administration[5]. It imparts a pleasant yellowish green colour to the fat in as low a concentration as 0·1% and has the further advantage of being easily detected by the red fluorescence of the melted fat in sunlight or more prominently in the ultraviolet light. In actual colouration, it is found that chemically pure chlorophyll is really not necessary and that the total chlorophyll pigment could be used conveniently at the rate of 1 lb. per every 1,000 lbs. of the fat. The crude pigment as isolated from leafy sources could be conveniently used with advantage. A suitable source for the extraction of the pigment is the leaves of *Spinaceæ oleracea* Linn. (spinach or palak) which gives 5% of the crude pigment. The leaves of *Clerodendron infortunatum* Gaertn. (pigment material, 3·5%) and the leaves of *Urtica parviflora* Roxb. (Indian stinging nettle) (pigment, 3·5%) are also found to be useful sources. The question of any physiological harmful effects does not arise especially when the pigment material is isolated from a leafy vegetable like palak (spinach).

I. *Extraction.*—The method followed is that of Willstatter and Stoll[6]. Since the presence of small amounts of other chlorophyll pigments does not materially affect the dyeing properties of the pigment, its purification according to the method of Schertz[7] has not been attempted. The fresh leaves are dried in the sun, powdered and passed through a 60-mesh sieve. The material thus prepared contains 8–9% of moisture. The powder (100g.) is stirred up in a beaker with 80% acetone (500 c.c.), kept for 15 minutes and then filtered through a Buchner funnel. The residue is pressed and washed with a further quantity (500 c.c.) of 80% acetone, when it becomes free of its green colour. The thick greenish filtrate is then dropped slowly into petroleum ether (200 c.c.) kept in a cylindrical separating funnel (2 lit. capacity). Subsequently distilled water (400 c.c.) is added, the contents gently shaken and the lower aqueous acetone layer is drawn off. This layer is usually brownish yellow with very little green tinge. If, however, it is still coloured distinctly green in thin layers, the above treatment is repeated using only 50 c.c. of petroleum ether and about 100 c.c. of distilled water. The reddish green petroleum ether solution is then transferred to a china dish and kept over paraffin wax (40°–45°C. m.p.) under vacuum. In about two days, petroleum ether is absorbed by the paraffin leaving behind the pigment as a dark green product which can be further dried over anhydrous calcium chloride to remove any moisture. From the aqueous solution, acetone is recovered by distillation. As suggested by Schertz[7], addition of a little sulphuric acid helps to reduce foaming during distillation. As regards petroleum ether, it is recovered from the paraffin wax by pressing out and subsequent distillation.

II. *Colouration* :—One part of the pigment (from spinach) is dissolved in sufficient quantity of the hydrogenated fat by raising the temperature to 80°C and is then mixed with the rest so as to make 1,000 parts. This contains 0·1 per cent of the pigment and gives a Lovibond Tintometer reading of 30 yellow and 4 blue in a ½ cm. cell.

III. *Stability to light and heat* :—A sample of 'chlorophyllized fat' is exposed to bright sunlight for a day in thin layers in a glass container. The colour fades (Tintometer readings given in the Table) but the sample exhibits a clear red fluorescence under the sunlight or ultra violet light. Moreover, it might be pointed out that for purposes of decolourization for adulteration, exposure of the fat in such thin layers in glass containers would not at all be feasible on a large scale.

Another sample is heated to 200°C. for one hour. The fat is not completely decolourized (vide Table) and exhibits a thick red fluorescence both in sunlight and in the ultraviolet light. The red fluorescence persists even after the sample is heated at 200°C. for 2 hours. But it is to be realized that such prolonged heating, with a view to destroy the colour to use it fraudulently for adulteration of ghee, is not likely to be attempted since it imparts a 'cooked taste' to the fat making it unpalatable. Furthermore, even 10 per cent addition of this discoloured fat to pure ghee can easily be detected by its red fluorescence under ultraviolet light (see Table).

IV. *Stability to oxygen.*—A sample of chlorophyllized oil is neither discoloured nor decolourized when subjected to aeration for one hour. The same stability is exhibited by the colour even when ozone is passed through the sample for half an hour.

V. *Absorption with animal charcoal.*—The chlorophyllized sample undergoes decolourization (vide Table) when treated in molten condition with animal charcoal. For complete removal of colour, however, repeated treatments may be necessary and it requires costly material like animal charcoal or Fuller's earth, and also necessary equipment for hot filtration on a large scale.

VI. *Microchemical Test for Chlorophyll.*—Even in samples decolourized by exposure to light and heat, the presence of chlorophyll can easily be detected by a simple colour test for magnesium[8] which is present in the chlorophyll molecule. In carrying out the test, the sample (100g.) is boiled for 30 minutes with concentrated hydrochloric acid (15 c.c.) and the acid layer separated in a separating funnel. The acid is partially neutralized initially with sodium carbonate, filtered and then completely neutralized to litmus with 4N alkali (sodium hydroxide). A red colour develops on the addition of aqueous titan yellow solution (0·2 c.c. of 0·1 per cent concentration) and 4N alkali (0·5 c.c.) showing thereby the presence of magnesium. A red precipitate gradually settles down to the bottom on standing and becomes quite prominent. The test is always compared with a blank simultaneously done under similar conditions. It is capable of detecting even 0·0002 mg. of magnesium per c.c. Thus even 1% adulteration with the chlorophyllized fat can be readily detected by this microchemical test.

TABLE

No.	Sample	Lovibond Tintometer			Red fluorescence		Test for magnesium
		Yellow	Blue	Red	In sunlight	In ultra-violet light	
1	0·1% chlorophyllized fat ..	30	4	..	Very prominent	Very prominent	Positive
2	0·01% sample (Sample No. 1 diluted ten times) ..	4	0·4	..	Prominent	Very prominent	Positive
3	Sample 1 exposed to sunlight for a day ..	28	0·5	2·0	Visible	Very prominent	Positive
4	Sample 1 heated to 200° for 1 hour	10	1	1·9	Pale	Prominent	Positive
5	Sample 1 passed through animal charcoal ..	2·4	..	0·1	Nil	Positive	Positive
6	Sample 4 diluted 10 times ..	1	..	..	Nil	Feeble	Positive
7	Pure ghee ..	2	..	0·5	Nil	Nil	Negative

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GAME SANCTUARIES AND NATIONAL PARKS IN WEST BENGAL

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Much of the wild life in this State, as elsewhere in India, is fading away—either due to the wanton destruction of the forests inhabited by game or due to their unrestricted slaughter by man. This has particularly been so in areas where there is no control of the State Forest Department.

Preservation of *all* wild life even on religious grounds, if any, can serve no useful purpose, as human interests must prevail whenever these are in conflict with the former. All right-thinking men have now realised the need of orderly and selective protection or preservation of wild birds and animals, as none will favour their total extermination nor their unchecked multiplication. A few examples of how some species have been extinct, or are on the verge of extinction will not be out of place here. *Rhinoceros sondaicus* the hornless rhino, which was once common in the tidal forests of the Sundarbans became totally extinct in the third quarter of the nineteenth century. In the grassy areas, interspersed with *hijal* trees (*Barringtonia acutungula*) in the district of Malda, Florican (*Sypheotides indica*), the well known game bird, was quite common even as recently as 1934–35, but due to ceaseless hunting by man on the one hand and depredations caused by the fearsome grey jungle-cat on the other, this bird has now become rare. The swamp deer (*Cervus duvauceli*) a graceful antelope, commonly known as "Barasinga", meaning a 12-pointer, exists now in small numbers only in the Game Sanctuary in a riverain forest (Jaldapara) in the western part of the Buxa Forest Division. Had the Jaldapara forest not been constituted a game reserve some twenty years ago, this antelope, as well as the one-horned rhinoceros, *Rhinoceros unicornis*, would possibly have by now ceased to exist in this State.

Apart from being a national asset, wild life has a very high place in sport and æsthetics. How many thousands of men, women and children flock daily to the Alipore Zoological Gardens. They do not see wild life in nature but they see it in captivity. Even then they go there many a time for pleasure and recreation.

At the rate at which population of West Bengal is increasing with the influx of displaced persons from East Pakistan, and consequently with the necessity for opening up more areas that have remained secluded so far, it is not difficult to foresee a time in the not-so-distant future, when large parts of this State will be devoid of the wild life that now exists therein. The opening up of remoter areas to accommodate the increasing population, the construction of new roads, and the large increase in the number of motor cars, etc., will considerably help poachers and thoughtless hunters to intensify their work of destruction of game. Protection and preservation of wild life in West Bengal is, therefore, a problem, that demands serious attention of all lovers of nature. It is most essential that there should be some legislation in this respect. The existing Wild Birds and Animals Protection Act, 1912, is hardly of any help in protecting wild life outside the Reserved Forests, in as much as the offences committed are non-cognisable. While, therefore, steps are being taken for the promulgation of a more stringent Act to be operative all over the State, we, the Foresters have been doing our share of this noble duty by forming large blocks of suitable areas of 'Reserved Forests' into Game Reserves or Sanctuaries. Some people seem to think that the claims of *forestry* and wild life are often in conflict with each other and that the objects and ideals of the two are sometimes antagonistic. But such ideas cannot be substantiated with facts at least in this State. Had it

not been for the unceasing efforts of the *Forest Officers* of this State, much of the wild life that still exists in reserved forests would have disappeared by now. In order to protect and preserve wild animals many of the forest officers had, in the past, and have, even now, to risk their lives in encountering thoughtless "sportsmen" or the "village hunters".

There are now five Game Sanctuaries in West Bengal, all managed by the Forest Directorate. Four of them are in the Forests of North Bengal and one, viz., the Lothian Island, in the Sundarbans of the 24-Parganas District, at the south-eastern corner of the State. The natural fauna in the remainder of the State has, as already pointed out earlier in this note, become almost extinct. Afforestation has been undertaken by, and existing private forests have been put under control of, the Forest Directorate in many of those districts mainly with a view to increase our forest areas. The possibilities of establishing National Parks where suitable species of wild animals and birds can be introduced are also under consideration of the Forest Directorate.

The largest Game Reserve in our State is the Jaldapara Reserve, with an area of 36 square miles. The area is situated on either side of the Torsa river in the Buxa Forest Division. Most of the area is subject to inundation by rivers and the vegetation is mainly tall grass and reeds with isolated patches of riverain tree species. Such localities provide excellent living conditions for a variety of animals including the one-horned rhinoceros, wild buffalo (*Bubalus bubalis*, Linn) and the swamp deer, and birds including pea fowls (*Pavocristatus*, Linn).

This area was constituted a Game Sanctuary as far back as 1932, mainly with a view to affording protection to rhinoceros. Since then the area has continually been parolled and carefully watched by the forest staff, and the rhino poachers have been given a very thin time. Protection has been successful, very few animals having been lost since the sanctuary came into existence, and the sadly depleted stock of rhinoceros is steadily improving in the peace and security of the Sanctuary. Many other species of wild game which frequent the Torsa jungles, have also benefited from the protection afforded to them, and the Jaldapara Game Reserve has now abundant stocks of most of the interesting wild animals that are found in West Bengal.

Although the rhinoceros often wanders many miles into the tree forest, his real home is dense jungle up to about 20′ high, which, with a few scattered trees, covers areas of the abandoned beds of the Himalayan rivers. Here he grazes most of the night and sleeps most of the day, wallowing in the hot weather in marshy pools with only his head above the mud. He is methodically indolent and sets a wonderfully straight course from mud-hole to grazing ground, and from grazing ground to his drinking pools in the clear gravelly streams. Contrary to what one hears of the African rhino, ours is seldom aggressive, nor does he cause havoc to agricultural crops like the wild elephant. He is entirely herbivorous and feeds principally on tall jungle reeds and grasses.

Of the other animals that share these haunts with the rhino, wild buffalo and swamp deer, the notable ones are hog deer (*Cervus porcinus*), sambhar (*Cervus unicolor*), barking deer (*Cervulus muntjac, Syn. Muntiacus muntjak, Zimm*), pigs (*Sus cristatus*), tigers (*Panthera tigris, Linn*) and python (*Python molurus*). Wild elephants though only too plentiful in the surrounding forest, give the rhino and his haunts a wider berth. The few species of game birds that are also common in the area are jungle fowl (*Gallus bankiva murghi*), green pigeon (*Crocopus phœnicopterus*) and Imperial pegeon (*Muscadivora ænea sylvatica*).

Apart from giving protection from the ravages of man, the forest staff specially employed therein have to carry out annual burning in the grass lands in order to prevent a profuse growth of seedlings of trees that eventually choke up the grass which contributes so much to the well being of the herbivorous animals. The Jaldapara Reserve is a favourite place of visit for

naturalists. In the recent past people from various parts of the world, have visited the Sanctuary and have taken photographs of animals, particularly of the rare species of Rhinoceros and swamp deer. With a view to offering intensive protection to this large area of game reserve, a proposal is under contemplation to constitute this sanctuary into a separate Range under independent charge of a Forest Ranger with adequate staff. The present strength of wholetime staff, consisting of one Deputy Ranger and 10 provisional Forest Guards has been found to be quite inadequate to look after 36 square miles of game sanctuary.

There is a road from Nilpara Range Office to Jaldapara Beat through the sanctuary. It is motorable during winter and is maintained with a view to facilitating better supervision and inspection of the Sanctuary.

Senchal Game Sanctuary.—This sanctuary covers an area of 15·27 square miles in the Darjeeling Forest Division. It was established with a view to affording protection to all species of indigenous fauna except the bear. The main species found in this area are barking deer, wild pig, goral (*Nemorhœdus hodgsoni*, Pocock), serow (*Capricornis sumatrœnsis*, Pocock), green-pigeon, khalij pheasant (*Gellœus leucomelanus*) and Imperial pigeon. All these species of animals and birds have been found, on a recent survey, to be increasing in numbers considerably. Monal pheasant (*Lophophorus impejanus*) was introduced in 1936, but did not survive. This is the only sanctuary in the Darjeeling Hills and, therefore, deserves special protection for the maintenance of the local fauna, particularly in view of the increasing number of so-called "sportsmen" in and around Darjeeling. There is no special wholetime staff employed for the supervision of this Sanctuary, but the local forest officers do some patrolling within the area, in addition to their normal forest work.

Chapramari Sanctuary.—The sanctuary comprises an area of only 3 square miles in the Jalpaiguri Forest Division. Due to the very easy accessibility of most of the reserved forest in the Jalpaiguri Division, it is extremely difficult to protect the game there. The game sanctuaries in this area, therefore, require stricter control than in other Reserved Forests. This sanctuary was constituted in 1939, in order to protect mammal, bird and reptile sections of the indigenous fauna. Progressively stricter measures of control have brought about an increase in the number of game, although the scarcity of most kinds of deer still persists.

Garumara Sanctuary.—This is the only area in Jalpaiguri Forest Division, where Rhinoceros still exists. The area of the sanctuary is about 3 square miles forming a part of the riverain forests alongside the Murthi river. Other notable species of wild life in the area are bison (*Bos gaurus*), hog deer, pig, sambhar, barking deer, tiger, green and imperial pigeons, and jungle fowl.

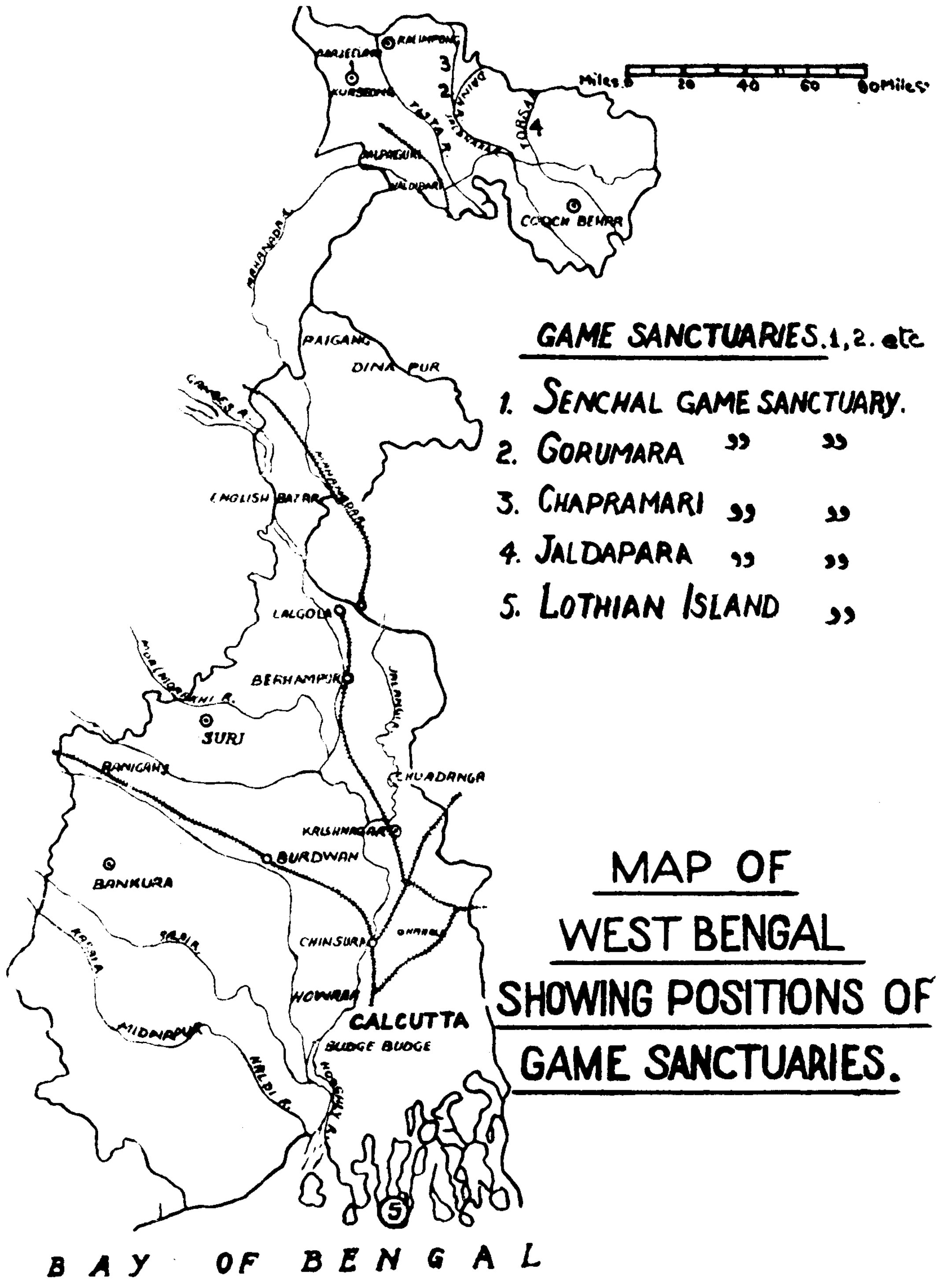
Lothian Island in 24-Parganas.—This island, with an area of 9,389 acres (14·6 square miles) situated at the mouth of the Saptamukhi river, was constituted a game sanctuary under a Government Notification in 1948. A census of the game at the initial stage was not attempted but it is known that the available game comprises mainly a small number of Cheetal deer (*Cervus axis*), pigs and a few tigers who do not always stay in this island. Barking deer and python cannot thrive in the area due to the excessive salinity of the water. It is proposed to dig a few ponds and bale out salt water therefrom for two or three successive years with a view to bringing in sweet water necessary for the continuance of the wild life that still survives in the area.

The regions most profuse in game in the Sundarbans having gone to East Pakistan, it is all the more necessary to protect and preserve the few specimens that still persist in our portion of these tidal forests.

RHINO

HOG-DEER (Stag)

TIGER



MAP OF WEST BENGAL SHOWING POSITIONS OF GAME SANCTUARIES.

It may be noted that the reserved forests (over which Government has absolute control) occur in (i) the two northern-most districts, viz., Jalpaiguri and Darjeeling, which along with West Dinajpur, Malda and Cooch Behar, have since 1947 been cut off from the rest of West Bengal, and (ii) the south-eastern bit comprising the tidal forests of the 24-Parganas. It is a happy augury that the State of Cooch Behar has been merged in West Bengal, making it possible to extend strict protection to the wild fauna of the forests of that district which is similar to that of the adjoining reserved forests of Jalpaiguri District. There are also 1,500 square miles of private forests in the districts of Midnapore, Bankura, Birbhum, Burdwan, Murshidabad, Malda and West Dinajpur over which a certain amount of State control began to be exercised recently. It would take sometime before actual management of these forests is taken over by the Government whose control will then become absolute as in the case of the Reserved Forests. Once this happens, it would be possible not only to stop the further depletion of the meagre remnant of wild life that is at present found here but also to restock these areas with suitable game animals and birds to the full holding capacity of these forests.

In all the most progressive countries of the world it is recognized that the time has come to train people not to look upon wild life as something to be destroyed at sight with stick, stone, arrow or gun but to acquire a respect and sympathy for these graceful and interesting denizens of the wilds and to admire the beauty of their form and movements. Snap-shooting of game has acquired large popularity in such countries. It is no longer the blood-thirsty *shikari* who boasts of having bagged the largest number of big or small game that is most respected, but the man who has engaged himself in a game which is more arduous, requires greater patience and skill, demands greater courage and betokens greater humanity, viz., the art of taking the most interesting snap-shots of wild life in their natural habitat.

While Zoos serve to create a certain amount of interest in and sympathy for wild animals and birds, the effect of Zoos on the minds of the people is somewhat artificial. It is only when people can see wild animals in their *natural* habitat that they really get to feel for them with all their soul. The reserved forests which alone actually contain a lot of wild life at present are, as we have seen, too far from the larger cities and towns to be of use as an educating factor for the general public. The establishment of National Parks within easy reach of the bigger urban units is the only effective solution. If such Parks are established and stocked with wild animals and birds which are given perfect protection, they will serve as ideal resorts for city and town-dwellers, tired with the rush and artificiality of urban life. And this is an ideal all right-thinking people should endeavour to achieve.

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CARE OF SHIKAR TROPHIES

M. D. CHATURVEDI, I.F.S.
Inspector-General of Forests, India

The preservation of *shikar* trophies constitutes the chief headache of sportsmen in our sub-tropical climate. However well cured the skins may be, they begin to deteriorate rapidly if they are not properly looked after. The nails drop off, the teeth begin to chip and the hair disappear in unsightly patches. Soon, one begins to despair of what was once a beautiful trophy and all that it stood for memories of tense moments and thrilling experiences.

2. Not unoften, the raw skin is ruined even before it gets to the taxidermist. The care of trophies must, therefore, begin from the moment the skin is taken off the animal. Most well-known taxidermists issue a book of words describing in detail the steps which should be taken to secure temporary immunity against the rapid deterioration of skins during transit. No sportsman could afford to be without such hints regarding the first-aid to be given to the skin before they are despatched to the taxidermists. One should keep his copy handy preferably in the rifle case.

3. During the Hyderabad 'Police Action', I lost irretrievably a record tiger and a fairly large bear skin, despite all the precautions I took in their preparation before despatch. The inordinate delay in transit led to the wholesale falling off the hair. The skins opened at the taxidermist's end in an advanced state of decay and had to be written off.

4. The taxidermist's instructions for the preparation and despatch of trophies, detailed as they are, require to be supplemented by the following precautions which are usually lost sight of :—

(*a*) Attend to the skins yourself. Do not leave them to the tender mercies of camp followers.

(*b*) Do not dry skins in the sun. Always put them under shade in fresh air.

(*c*) See that all fat, flesh, blood and dirt have been scrupulously removed of all things BEWARE of FAT.

(*d*) Before packing, spray them with a solution of arsenic pentoxide from a flit pump. Give a generous application of arsenic on paws, lips, edges and bends. Let arsenic dry before packing. Fold so that hair touches hair and the fleshy side touches itself.

(*e*) Despatch your skins by passenger, and not goods train.

(*f*) Always insure them.

5. It is when the trophies return from your taxidermist and adorn your drawing room, that they demand continuous attention. Experience gained by me during the best part of a quarter of a century suggests the following measures :—

(*a*) Keep your skins, heads and horns on the walls, away from the reach of children, dogs and cats.

(*b*) All trophies must be kept in a fresh stream of air which is the best disinfectant. The room where trophies are kept must have all its windows open at least during the day.

(*c*) Dust which gets lodged in the roots of hair is the worst enemy. Brush your skins thoroughly at least once, if not twice a month. Brush, all bends, edges and back of neck briskly.

(*d*) Teeth, nails and horns should be waxed once a month. Use beewax and turpentine boiled together or white shoe cream for the purpose.

(*e*) When skins have to be packed in boxes, e.g., in the event of a transfer, brush them and spray them with arsenic pentoxide, applying it more generously to the bends, edges and backs of necks. Use a flit pump.

6. I have tried scores of well-known insectisides, but I found none so effective as arsenic pentoxide. Make a saturated solution of it in a bottle of hot water. Fill the solution in a flit pump and spray your trophies before and after the monsoons. The purchase of arsenic requires special permit from the District Magistrate and can be had from any of the large importers of chemicals. Both the pump and the bottle should be promptly labelled as 'Poison' (in English and vernacular) and kept under lock and key. The cork of the bottle containing arsenic solution should be pressed home, so that it cannot be taken out without a cork screw. The precaution sounds as silly as it is effective.

FORESTRY AND BEE-KEEPING IN KULU

BY D. P. SINGH, D.F.O.
Kulu

SUMMARY

Kulu has been an important source of honey, but due to excessive grazing, browsing and burning of forest vegetation which forms the bee pasture, the production has suffered a serious set-back in recent years, so much so that the bee-keepers are now getting anxious about the industry. Afforestation in Kulu, is to the bees what grow-more-food is to the people in general. The relation between forestry and bee-keeping is very intimate and incidentally in Kulu, the species useful as bee-flora are also of great utility for general needs and soil stabilization. We must, therefore, do our best to protect, extend and improve the bee-flora before it gets too late.

Kulu—the valley of gods—is said to have been once flowing with milk and honey like the rest of India. It may be rather hard to believe in respect of milk production, in view of the prevailing low average of 2 *chhataks* of milk per cow, but the case of honey sounds quite plausible for the sources are there, and which obviously have been lost owing to perpetual ignorance and neglect. With a little care and attention to the available pasture for bees and afforestation of areas with suitable species, the production of honey can be increased manifold and slowly but surely brought to the level of the past.

There are generally two distinct crops of honey, i.e., during June and November. The June takings are rather poor both in yield and quality. The autumn crop yields on an average about 4 seers per hive. Nearly every house in the valley has its beehive in the wall. The practice of beating pots and pans to induce swarms of bees to settle down still prevails in some parts of Kulu and while this is done the owner of the hive and his friends call out—

> "*Besh manhun, besh, age jasi, ta*
> *manhun rane ri drohi hosi*".

"settle, my bees, settle down, we have taken the oath of your King, so go no further". And yet we find that the number of hives and consequent production of honey is decreasing every year. Few of us have thought that all the noise and swearing-in-ceremony, will not save the industry from decline. We have to seek the causes elsewhere and remedy them before it is too late.

Every forester knows what part bees play in pollination of some of our important species, but few appreciate the effect of the extent and the distribution of our forest growth on the propagation and very existence of the hives. In fact it will not be wrong to say that bee keeping in Kulu is mainly dependent on Forestry and as such it should be of greater concern to the forester than to the agriculturist. A perusal of the list of some of the important plants that afford accessible nectar and pollen to the bees will amply support the above contention.

The bee pasture available in Kulu is of varied extent and importance. Generally major and minor sources of nectar and pollen may be distinguished. Both these sources deserve propagation and protection—major source for obtaining storing capacity and surplus crop and minor source for providing the colony with nectar and pollen and thus enable it to survive at times when there is a general scarcity of bee-flora. If the nectar and pollen are available in abundance during early spring, the bees are able to build up rapidly and soon attain storing strength. After this they naturally begin to work for the bee-keeper if the subsidiary sources of accessible

nectar are available at that time. Likewise with rich bee-flora during autumn, bees pile up more surplus for bee-keeper and also enter winter with large number of young bees and adequate reserve food to enable them to start brood-rearing in winter to insure spring prosperity.

SPRING CROP

For spring crop of honey the major source of nectar and pollen is *Berberis*. Ordinarily the flow from this genus is erratic. *Berberis lycium* and *Berberis aristata* are the two species of importance in this connection. Both bloom during May in the valley and constitute important source of nectar. The honey obtained from *Berberis* is not of good quality as it is of dark red colour with strong flavour. It is said to be of good medicinal value but is generally not liked and sells at cheaper rates. In fact some bee-keepers in Kulu do not care to extract this honey and leave it in the hives for use of the bees.

Wherever *Cedrela serrata* (*daral*) is met with the June takings are fairly good. *Daral* flowers in June and is a sister plant of '*tun*'—an important nectar producing tree in Kangra. The propagation of *Cedrela serrata* with 'soapnut' will certainly improve the bee-flora of the valley and will result in bigger, better and surer crop of honey in spring. Both being tree species their nectar secretion is not affected by failure of rains as is the case with shallow rooted shrubs. Willow is another bee plant for spring-crop. It flowers towards the end of winter and provides large quantities of nectar and pollen so very important for early brood rearing. Other plants which constitute good sources of honey for spring crop are *Pomegranate* (*Punica granatum*), *shisham* (*Dalbergia sissoo*), *puna* (*Ehretia acuminata*), wild berries (*Rubus sp.*), wild rose (*Rosa moschata* and *Rosa macrophylla*) and fruit trees—apples, pears, plums and cherries, etc.

AUTUMN CROP

This is the crop which fetches fair income to the farmers. The main source of this honey is *shain* (*Plectranthus sp.*). This plant is, therefore, a money plant of the valley and deserves all the protection. It is grown abundantly throughout Kulu, flowers during September–October and constitutes the major source of collection of honey at the end of October. The honey is of very good quality from water white to white in colour and brings good income to the bee-keepers. There is generally no dearth of bee-flora for Autumn crop. Other species besides agricultural and horticultural plants are *Origanum vulgare*, wild white clover (*Trifolium repens*) *Strobilanthes*, *Polygonum*, etc.

Generally speaking most of the species mentioned above, particularly soapnut, *Cedrela serrata* and willow are already receiving due attention in our afforestation programmes in the Division. This combined with closure scheme of the areas bearing over-grazed crop of 'shain', *Berberis*, etc., is bound to improve the production of honey in future years. In our Soil Conservation and Afforestation scheme due attention is also being paid to the protection of bee pastures already available in the valley against excessive grazing. Cultivation of new areas far removed from habitations where otherwise wild vegetation is flourishing is being discouraged in the interest of production of more honey—an essential food for all.

MANGO CHARM

BY BALWANT SINGH

(Conservator of Forests, Chamba)

SUMMARY

An excellent cure for waspsting is hidden in the inflorescence of mango, which can be so easily made use of by the Forest Officers and Labour.

One day I was sitting with an advocate friend of mine when an old man brought his crying child in his arms to the bar-room and requested my friend to make use of his charm in order to relieve the pain of the child who had been stung by many wasps on his arm and hand. My friend made the child sit in a chair, murmured something in whispers and frequently passed his hand on the arm and hand of the child, till it stopped crying and told his father that he was completely relieved of the pain. The child comfortably walked back home.

Some said it was hypnotism, others said it was the effect of some vedic mantra or an Ayat from the holy Quaran which relieved the pain, but my friend silently listened to all these comments and refused to discuss the matter. Later that every evening when we met again I inquired of my friend how he managed to relieve the pain of the child so wonderfully; but he simply answered that his Guru (the benefactor who showed him the way) forbode him to divulge the secret to any one else. He refused to be communicative on the subject though pressed again and again.

2. One evening I found him in a very happy mood. He had won an important case in the court, for which he had obtained a fat fee and thus was evidently proud of his achievement. Catching him in this happy mood, I took a promise from him to answer a question of mine correctly to be best of his knowledge; and he kindly agreed to do so, presuming that the question probably related to the case that he had won. He was taken aback when I requested him to tell me how he relieved the pain of the child who suffered from the wasp slings the other day. Lo, all his mirth disappeared, he remained silent for a long time and seemed to be seriously contemplating the answer. He asked me if I would keep the secret to myself only. I replied that if it was really a dangerous weapon in the hands of others I would keep it to myself alone. He simply laughed and said "Dangerous ? Oh no, it is not at all dangerous. In fact it is too simple to be believed" and out he came with his secret which follows :—

"Take inflorescence of mango before it is ripe, rub it between your hands and let it dry. Try it 3–4 times again on subsequent days. It will impart to your hands the charm exhibited by me".

I asked him about the Mantra or the spell repeated by him. He replied that there was no such thing. He had simply pretended to recite something in order to make the person believe that he really possessed something of the nature of the charm.

3. The efficiency of the medicine I have since tested myself with success. Although, the inflorescence is rubbed 3 or 4 times only, its effect lasts for full one year till the tree flowers again. As I had given no such promise to my advocate friend to keep it a secret, I am using your columns to broadcast it to the readers of the Magazine, so that they may usefully try it themselves. Out in the forest, the Forest Officers and the labourers are liable to be stung by wasps and here lies an in-expensive relief.

The chemists can reveal the hidden chemical possessing such wonderful healing property.

4. It is possible that in the same manner many other forest officers may be in possession of nature's secrets learnt from Sadhus who often visit our forests in search of rare medicinal herbs. I would suggest that they may kindly make use of the *Indian Forester* in conveying the benefit to the others and thus prove of service to the ailing humanity.

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THE SOILS OF THE *CASUARINA* PLANTATIONS WITH SPECIAL REFERENCE TO THE CAUSES OF CASUALTIES (WHOLESALE AND IN PATCHES) IN SOME OF THE AREAS

BY DR. RAGHUNATH S. GUPTA, M.SC., Ph.D. (LEEDS)

Soil Chemist, Forest Research Institute, Dehra Dun

The present paper is based on the observations made by the author during his inspections of the casuarina plantations of Madras and Orissa, which were undertaken to investigate the causes of mortality and poor growth of this species in those localities.

Problem in general.—As is well known, casuarina (*Casuarina equisetifolia* Forest) is a quick growing hardwood species of high calorific value, which gives a very good fuel wood. At the same time it is supposed to make very light demand on the soil as it is said to grow in very poor localities. Its plantations are consequently raised at a variety of places in order to solve the problem of local fuel supply. It is, however, found that in certain plantations there are large scale casualties and in many others the plants are dying in patches or have poor growth. During December '49 and January '50, the Central Silviculturist and the Mycologist did a joint tour of several plantations. Amongst the many causes of failure of the plantations, it was suggested that the attack by the fungus *Trichosporium vesiculosum* might be the main cause of the casualties. It was stated by the Mycologist that this fungus is most active just before the rains. Consequently a joint tour of casuarina plantations was undertaken by the Assistant Mycologist and the Soil Chemist during June–July 1950. Sriharikota island plantation and the Padugai plantations in Madras and Balukhand (Puri) plantations in Orissa were visited. For want of time, more plantations could not be visited. The present paper is therefore based mainly on the observations made in the plantations raised in the above localities.

As has already been stated, one of the causes of failure of casuarina was alleged to be the attack by *Trichosporium*. Apart from this it was also believed by some responsible forest officers that moisture deficiency due to various causes, also limits the growth of this species. These views were therefore kept in mind while making our field observations and collecting soils for laboratory study. In view of this and other reasons, the main factors studied from point of view of soil were the relationship of the growth of casuarina to the following factors :—

(i) incidence and existence of the fungus *Trichosporium vesiculosum* from soil point of view ;

(ii) *pH* of different layers of soil in relation to the healthy growth, as also casualties in casuarina, with special reference to the existence of *Trichosporium* ;

(iii) depth of water-table in relation to the existence or non-existence of (or casualties in) casuarina ;

(iv) content of moisture in different soil layers and their relationship to the existence of casuarina ;

(v) morphology of the soil profile in general and its relation to casuarina growth ; and

(vi) existence of root nodules, the bearing of moisture (including the depth of water-table) and *pH* of the soil on their existence, and the influence of these root nodules on the existence and growth of casuarina.

With a view to studying the problem from the above angle, the field work was done as follows :—

(1) examination of the soil-site characteristics in different typical areas ;

(2) study of the soil profiles in these areas ;

(3) determination of the *pH* in the field for the different layers of soil profiles in pits dug and examined, with the help of field outfit ;

(4) determination of soil moisture in the different layers of soil profiles, with the help of field outfit ;

(5) rate of percolation of water at different depths of the soil in pits, in order to have some idea of porosity and also probable ascent of water from the water-table ;

(6) hardness of soil at different depths in a pit with the help of a Field Hardness-Tester ;

(7) measurements of the Depths of Water-Table in relation to Casuarina growth ; and

(8) photographs of special interest.

Sriharikota island plantations.—The casuarina plantations visited in the island were at Kothachenu, Ravanapachatram, Ponna, Chennagarupalem and Sondla Doruvu. Excepting Ponna, which contained second rotation crop, most of the areas visited had been planted with casuarina for the first time. In general, the areas with respect to the condition of plantations and general soil characteristics could be divided into the following groups :

(1) Ponna and Coastal strip of Sondla Doruvu (about a furlong along the sea coast) with healthy casuarina growth.

(2) Ravanapachatram and inland strip of Sondla Doruvu (about one furlong away from the sea) with large scale casualties.

(3) Kothachenu and Chennagarupalem which are inland plantations with casualties in patches.

The general characteristics of soils in these areas are discussed below :—

Ponna and Sondla Doruvu (along the sea-coast).—This is an area with healthy growth of casuarina and is running along the coast of the Bay of Bengal, extending inland to a depth of less than a furlong. The soil is mostly quartzose sand with no definite soil horizons. It is, however, noticed that in some places there is a large admixture of shells, particularly in the lower layers of the profile, especially in the coastal areas, which gives to the soil a slightly alkaline reaction, taking the *pH* to near about 8 in some cases. This mild alkalinity has however, no bearing on the existence or otherwise of casuarina, as there are areas with sub-soil

pH 8 and *pH* 7 where both healthy and unhealthy growth of casuarina occurs. This is discussed more fully later on. The soils in this area have the following typical profiles :—

Ponna series Pit 2

0″–3″	A light greyish yellow soil with sandy texture. *pH* 6·7, Moisture + *.
3″–72″	Light yellow coloured soil, with sandy texture. *pH* 7·0, Moisture increasing with depth from ++ to +++ (for depths below 48″). Water-table about 12–15 feet.

Sondla Doruvu series, Pit 2 (with healthy growth).

0″–6″	Light yellow. Sandy. *pH* 7·1, Moisture +.
6″–14″	Light yellow. Sandy. *pH* 7·4, Moisture ++.
24″–72″	Light yellow. Sandy. *pH* 7·9, Moisture ++. Water-table 12–15 feet.

Ravanapachatram and Inland strip of Sondla Doruvu (Western portion, within a furlong from the Bay of Bengal).—The two areas from a strip to the west of the above area and lie about a furlong away from the sea coast. It runs north to south, more or less parallel to the coastal line. In this strip, particularly Ravanapachatram, there are large scale casualties. The conditions of the top-soil generally appear to be drier here than in the area discussed above, though actually the water-table is not lower and may perhaps be higher. General characteristics of the soil are given below :—

Ravanapachatram. (Pit 1, in an area with 80% casualties).

0″–5″	Light brownish yellow with streaks. of greyish yellow. Sandy texture. *pH* 6·6, Moisture 0.
5″–52″	Light brownish yellow. Sandy. *pH* 6·5, Moisture +.
52″–72″	Light brownish yellow. Sandy (coarser than above). *pH* 6·6, Moisture ++. Water-table 10–12 feet.

Pit 2, in a patch of good growth. Height of trees 25 feet. (Average).

0″–4″	Light brownish grey. Sandy. With some organic matter (nutrients). *pH* 6·0, Moisture 0.
4″–16″	Light greyish brown. Sandy. *pH* 6·5, Moisture +.

* Degree of moisture is noted here according to the method suggested by G. R. Clarke in his book "Study of Soil in the Field" (1936), p. 100, as follows.—

0	means	Air dry.
+	,,	Weakly moist.
++	,,	Moist but changes colour on wetting.
+++	,,	No change of colour on wetting (Field Moisture Capacity or Moisture Equivalent).
++++	,,	Waterlogged.

16″–58″ Light brownish yellow. Sandy.
pH 6·7, Moisture ++.

58″–72″ Light brownish yellow. Sandy.
pH 6·7, Moisture ++.
Water-table 10–12 feet.

N.B.—It is to be noted that in the good patch there is plenty of humus (therefore nutrients) mixed with top-soil layers. This patch appears to have been an old nursery bed.

Sondla Doruvu (Inland strip).

Pit 1, between two trees attacked by *Trichosporium vesiculosum*.

0″–4″ Light yellow. Sandy.
pH 7·1, Moisture +.

6″–24″ Light yellow. Sandy.
pH 7·2, Moisture ++.

24″–72″ Light yellow. Sandy.
pH 7·5, Moisture ++.
Sand coarser grained than above.
Water-table 12–15 feet.

Pit 3, in an area with 60% casualties.

0″–6″ Light yellow. Sandy.
pH 7·0, Moisture 0.

6″–24″ Light yellow. Sandy.
pH 6·9, Moisture +.

24″–48″ Light yellow. Sandy.
pH 7·3, Moisture ++.

48″–72″ Light yellow. Sandy.
pH 8·0, Moisture ++.
Sand coarser grained than above.
Water-table 12–15 feet.

N.B.—Characteristics of soil with *Trichosporium* attacked trees are more or less the same as soil with 60% casualties due to various causes. There does not appear to be any special soil features which could be ascribed to the former alone.

Kothachenu and a major portion of Chennagarupalem.—These are inland plantations where casualties are seen to occur in patches. As against the coastal plantations, these inland plantations have either no shells or even if present their proportion is very low in the sub-soil. Consequently the sub-soil shows more or less neutral or slightly acidic reaction. The surface soil is rendered slightly acidic due to admixture or slight amounts of humus formed from the decomposed casuarina needles. The general characteristics of the soil profiles are given below—

Kothachenu.

Pit 2, in a natural forest area.

0″–7″ Greyish light yellow. Sandy.
pH 6·2, Moisture +.
Slight organic matter present.

7″–26″ Greyish light yellow. Sandy.
pH 6·2, Moisture +.

26″–48″ Light yellow. Sandy.
pH 6·3, Moisture +.

48″–72″ Light yellow. Sandy.
pH 6·6, Moisture ++.
Sand coarser grained than above.
Depth of water-table 10–12 feet.

Pit 3, in an area with good growth (average height 30 feet).

0″–7″ Greyish light yellow. Sandy.
Slight organic matter present.
pH 6·4, Moisture +.

7″–24″ Greyish light yellow. Sandy.
pH 6·4, Moisture +.

24″–48″ Light yellow. Sandy.
pH 6·4, Moisture +.

48″–72″ Light yellow. Sandy.
pH 6·4, Moisture +.
Depth of water-table 10–12 feet.

Pit 4, in an area with 80% casualties.

0″–5″ Greyish light yellow. Sandy.
pH 6·2, Moisture ++ *.

5″–24″ Greyish light yellow. Sandy.
pH 6·2, Moisture ++ *.

24″–48″ Light yellow. Sandy.
pH 6·6, Moisture +.

48″–72″ Light yellow. Sandy.
pH 6·6, Moisture +.
Depth of water-table 10–12 feet.

Pit 1, near a tree attacked by *Trichosporium vesiculosum.*

0″–5″ Light yellowish grey. Sandy.
pH 6·2, Moisture +.
Slight organic matter present.

5″–39″ Light greyish yellow. Sandy.
pH 6·2, Moisture +.

39″–72″ Yellow. Sandy.
pH 6·4, Moisture ++.
Depth of water-table 10–12 feet.

It may be noted in the case of above profiles that the *pH* range is more or less the same for soil in natural forest, area with good growth, area with 80% casualties and area with fungus (*Trichosporium vesiculosum*) attack. With regard to other characteristics, the only difference is that in the case of soil with 80% casualties there is lesser amount of organic matter

* High moisture in top-soil layers in due to half an inch of rain during the night previous to inspection.

(nutrients) and lesser depth of its penetration in the soil as compared with natural forest and area of good growth. These points are, however, discussed more fully later on.

Chennagarupalem : Two areas were taken namely the one in which there was a good growth of casuarina and another which was a failure. In the latter, the indications were that the area remained water-logged during rains.

Pit 1, in a good growth area, average height of trees about 25 feet.

0″–5″ Light yellow. Sandy.
pH 6·6, Moisture +.

5″–24″ Light yellow. Sandy.
pH 6·2, Moisture +.

24″–48″ Light yellow. Sandy.
pH 5·7, Moisture ++.

48″–72″ Above horizon more or less continues.
pH 6·3, Moisture ++.
Water-table about 10 feet.

Pit 2, in an area with 80% casualties ; water-logging during rains suspected ; extensive insect attack.

0″–4″ Light greyish yellow. Sandy.
pH 5·7, Moisture +.
Slight organic matter present.

4″–14″ Light greyish yellow. Sandy.
pH 5·4, Moisture ++.

14″–36″ Light yellow. Sandy.
pH 6·1, Moisture ++.

36″–72″ Light yellow. Sandy.
pH 6·5, Moisture ++.
Water-table about 8 feet.

pH of soil as related to the growth of casuarina.—It was seen that both healthy and unhealthy growth of casuarina appear to occur in soils with *pH* ranging from 6 to 8.

The following table will illustrate this.

TABLE I

Area	Pit No.	Condition of plantation	*pH* of soil at depths Top 0″–12″	Middle 12″–48″	Bottom 48″–72″
Ravanapachatram	1	80% casualties	6·6	6·5	6·6
do. ..	2	Well stocked ; Av. Ht. 25 feet	6·2	6·6	6·7
Ponna ..	1	70% casualties	6·8	6·9	7·0
do. ..	2	Well stocked ; Av. Ht. 30 feet	6·8	6·9	7·0
Kothachenu ..	4	80% casualties	6·2	6·6	6·6
do. ..	3	Well stocked ; Av. Ht. 30 feet	6·4	6·4	6·6
Chennagarupalem	2	80% casualties	5·6	6·1	6·5
do. ..	1	Well stocked ; Av. Ht. 25 feet	6·4	5·7	6·3
Sulla Doruvu ..	3	80% casualties	7·0	7·3	8·0
do. ..	2	Well stocked ; Av. Ht. 35 feet	7·3	7·9	7·9

Since the soils with all ranges of *pH* bear both healthy and unhealthy growth of casuarina as well as heavy casualties, it is not possible to say that the *pH* of soil influences the success or failure of casuarina. The nature of the soil in this area was throughout sandy but the same trend is seen with other types of soils, viz., in the Padugais where loams and clays occur. This will be discussed later on.

pH and incidence of Trichosporium vesiculosum in sandy soil.—In order to see whether *Trichosporium* attack is confined to soils of any particular range of *pH*, the soils occurring near the trees attacked by this fungus were examined. Examination revealed that the attack was found in all ranges of soil *pH*. Also, in the same *pH* range there were groups of healthy as well as fungus attacked trees. Following representative figures are given to illustrate this point. Same trend of results was found in other areas also, e.g., in non-sandy soil in Padugai plantations which will be discussed later on.

	pH of soil at depths		
Alkaline pH range (coastal area)	Top 0″–12″	Middle 12″–18″	Bottom 48″–72″
Sondla Doruvu, Pit 1, between two trees with *Trichosporium vesiculosum* attack	7·2	7·5	7·5
Sondla Doruvu, Pit 2, in a group of healthy trees ..	7·2	7·9	7·9
Acidic pH range (inland plantation)			
Kothachenu, Pit 1, near a tree with *Trichosporium vesiculosum* attack	6·2	6·2	6·4
Kothachenu, Pit 3, in a patch of healthy trees ..	6·4	6·4	6·6

It will be seen from the above that this fungus attacks the trees, both in the alkaline as well as the acidic soil. Perhaps the most important zone of soil in this case is the top 0″–6″ layer as the Mycologist's report states that the attack of fungus by spores is mainly at the base of the tree. It is significant that the *pH* value of this top layer of soil, in the case of both the attacked and healthy trees varies from 7·2 to 6·2. It is, therefore, not the soil but some other factor which might be favourable at the time of attack of the fungus, e.g., it may be favourable moisture condition. It has, however, nothing to do with any permanent and lasting soil property such as *pH*, soil texture, or organic matter content, etc. The last factor, namely, organic matter of course, appears to play an important role in the root development and good growth of casuarina, as will be discussed later.

Effect of water-logging on the growth and existence of casuarina, and accumulation of humus.—It was noticed in certain areas (e.g. Pit 2 in Chennagarupalem) that due to water-logging during rains, the humus in the upper layers decomposes comparatively slowly. It consequently accumulates and therefore increases the acidity of the soil. Ordinarily this accumulation of humus would have helped casuarina but it looks as if water-logging during rains is a limiting factor. At several places such patches of failure are noticed. These are blanks with green ground cover. But in adjacent mounds patches of good growth are seen. Here the soil on the surface and even up to 24″–48″ depth appears to be well supplied with humus and nutrients but without the disadvantage of water-logging. Most of such patches where good growth occurs appear to have been old nursery beds. In such places deep tap roots develop due to fertile sub-soil. This initial development of deep tap roots has helped the plants to survive.

As against the above observation, however, there are reports to show that water-logging has no adverse effect on casuarina. It has been observed by Raghavan (1) quoting Mr. Jogiraju in connection with the Vizagapatam plantations "that in some private plantations casuarina is growing well in highly water-logged situations and even in places where water accumulates in the rainy season to a depth of 3 feet for some months. Here trees threw out long adventitious roots which float on the water to obtain the air required. When the water subsides, the roots come into contact with the soil, penetrate into it and grow like ordinary roots". Similar evidence is available with regard to casuarina plantations in Orissa (2, 3). But against such opinion with regard to the tolerance of casuarina for water-logged areas, there are many references in literature which indicate that water-logging is detrimental to casuarina (4). It has been stated in the Godavari Lower Division working plan for 1934–44 that "there are two low-lying strips of land at the S.E. end of the plantation which are water-logged during rains and where casuarina will not grow" (5). Troup has stated with regard to *Casuarina equisetifolia* that "on badly drained ground subject to inundation it tends to become unhealthy and die off" (6).

Root nodules as related to the growth of casuarina and the bearing of soil texture and moisture on their development.—In order to obtain some idea of the condition of roots of healthy and dying or dead trees (including those attacked by *Trichosporium vesiculosum*), some roots were exposed for examination and photograph. It was found that in the case of healthy and tall trees the root nodules were in abundance while in the case of the dying or dead trees (including those attacked by the fungus) these were very sparse, mostly dried or shrivelled up and very miserable looking. Photograph No. 1 shows the roots of a dying tree. It is generally noticed that the root nodules are mostly confined to the upper foot or two of the soil depth and the camera was focussed particularly on that portion. In the case of this dying tree, the root nodules were very sparse and whatever were present were shrivelled up or dried.

Roots of another tree, which was healthy, are shown in Photo No. 2. The root nodules are very profuse and in abundance. Due to these root nodules, adequate amount of nitrogen is supplied to the plant by fixation of atmospheric N and this consequently helps its growth. In a poor sandy soil like that of Sriharikota, the development of root nodules is particularly essential to casuarina growth, because this is by far the only source of supply of nitrogen to the plants. For a healthy development of these root nodules, the top soil should have adequate moisture or the atmosphere should be humid enough, as in the immediate vicinity of the sea coast where moist sea breeze with plenty of water spray is blowing past the base of trees. Since root nodules occur in the top two feet or so on the soil, a lot depends on the adequate supply of moisture in this top layer. With insufficient moisture the root nodules start drying up, thus cutting out to the tree the only source of supply of nitrogen in poor sandy soils. Consequently the trees die not only due to moisture deficiency but also due to lack of nitrogen. In Ponna where Photograph No. 2 was taken, and in Sondla Doruvu coastal strip, the sea breeze brings in plenty of sea water spray from the Bay of Bengal, and this keeps the soil at the base of trees sufficiently humid thus facilitating the healthy growth and development of root nodules which fix the nitrogen necessary for the plants. In case of Ravanpachatram and inland Sondla Doruvu areas, the top soil gets desiccated. This kills or arrests the growth of root nodules, which is responsible for large scale failure of plants, even though the water-table is more or less the same as in the coastal strip. But even in the Ravanappachatram locality there

(1) RAGHAVAN, M. S. (1946). *Seventh Silvicultural Conference.*
(2) SHARMA, A. R. (1946). *Loc. cit.*
(3) ANON, (1933-34). *Annual Progress Report of Forest Administration in Bihar and Orissa.*
(4) SALAR, SYED. (1937). *Quarterly Journal of Mysore Forest Deptt.* 5 (13).
(5) CORNWELL, R. B. (1934). Working Plan of Godaveri Lower Division.
(6) TROUP, R. S. (1921). *Silviculture of Indian Trees.*

PHOTO 1

Roots of a dying (but not dead) casuarina tree in a *Sandy Soil* are shown. There are not many root nodules, and even amongst the existing ones, most are dried up. Consequently there is *nitrogen deficiency* in a *poor sandy soil.*

Locality :—Kothachenu (Sriharikota) Cpt. 11, 1945 plantation (Pit 4).

Date : 17-6-50.

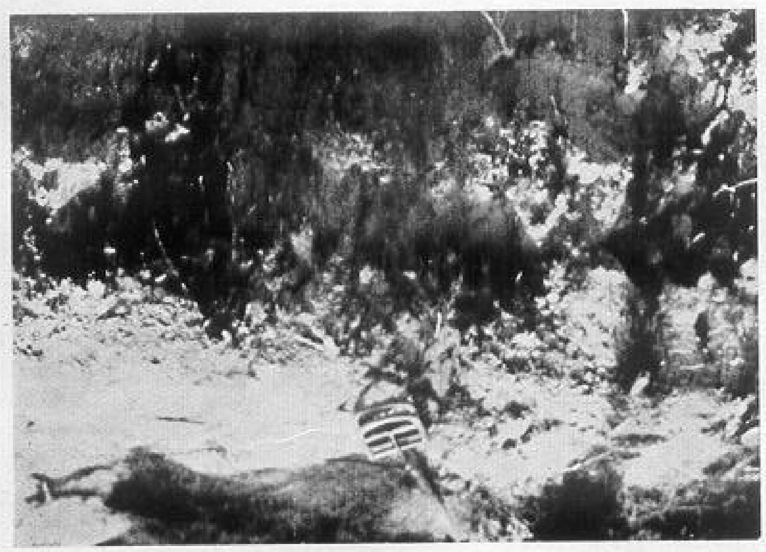


PHOTO 2

Roots of healthy casuarina tree in a *Sandy Soil* are shown. Development of profuse healthy root nodules help to supply *nitrogen* to the plant, by fixation of atmospheric N. Soil being poor sand, the fixation of atmospheric N. is the only source of supply of this element.

Locality :—Sondla Doruvu (Sriharikota), Cpt. 6, 1945 plantation (Pit 2).

Date : 19-6-50.

PHOTO 3

Roots of a healthy casuarina tree in a fairly *rich loamy soil* are shown. The development of root nodules is not so profuse as in sandy soil, yet healthy growth is possible because a rich loamy soil has its own supply of nitrogen and the tree does not depend entirely on fixation of atmospheric N. by root nodules.

Locality :—Sithalavai (Padugais), 1944 plantation (Pit 1).

Date : 26-6-50.

are patches of good growth and these are mostly old nursery beds which had been heavily manured in the past. Their rich top soil supplies the necessary nitrogen to the plants, and helps their survival and growth. In the inland plantations of Kothachenu and Chennagarupalam also these root nodules appear to play an important role.

When compared to a sandy soil like the one in Sriharikota, in the rich loamy type of soil found in the Padugais the root nodules are perhaps less important. Photograph No. 3 was taken of the roots of a healthy tree in Sitalavai in the Padugai plantations on the banks of the river Kaveri, where the soil is a rich alluvial loam. Age of plantation was more or less the same as in the two cases discussed above. It is seen that even though the root nodules are not so profuse as in No. 2, the trees are tall and healthy. Here the casuarina tree does not depend entirely on the fixation of atmospheric N but draws its nitrogen supply from the rich loam itself and thrives on it. Importance of manuring in a sandy soil is thus evident.

Moisture and humus as related to the growth of casuarina trees.—For a healthy and vigorous growth of casuarina plants, the development of a good tap root is essential and this requires adequate supply of moisture and nutrients, especially nitrogen. Good tap root development in the initial stages of growth is very necessary for the later development of the tree and the author will revert to this factor again while discussing Balukhand (*Puri*) plantations where it is evident that with insufficient root development the tree remains small and bushy. Apart from the supply of nutrients as discussed in previous section, an adequate supply of moisture (but not water-logging) is very essential for the root development and later growth of casuarina. In the case of a sandy soil it is all the more important, because in it, the capillary ascent of water is not so good, especially when the sub-soil sand grains are very coarse. It is significant that most of the casualties occur when artificial watering is stopped after a couple of years of planting. The usual practice in Sriharikota is to water the plants for two years after transplanting at the rate one/fourth pot (110 oz.) once in three days during dry season. This artificial watering is stopped after two years during which period (i.e. first two years) there is 80% survival. Most of the casualties seem to occur during the third and the fourth years, when the watering has been stopped. Perhaps a modification of plantation technique, such as deeper planting, may help better tap root development during the 3rd and 4th year as its roots would then have developed sufficiently to reach the capillary water zone near the water-table. Incidentally, under a well grown forest, the trees will give good shade to the surface soil, which will not become then too desiccated and allow root nodules to develop well in cool moist soil. In a well stocked area the shady condition also allows humus to accumulate in the surface soil which forms a mulch and further helps to conserve moisture. At the same time humus is a source of supply of nutrients to casuarina and helps its growth.

Padugai plantations.—These Padugai plantations occur between the South bank and the South flood banks of the Kaveri river. Along side the flood bank a channel runs more or less parallel to the strip of the Padugai plantations; thus the plantations are sandwitched between the river and the channel.

The Forest Officers generally believe that the casualties in casuarina in these plantations are mainly due to drought, as there had been long periods of drought during the past few years. Particularly in 1950 the rains had failed, and the Kaveri river which should have been in floods by the end of June 1950, had very little water flowing in it, so much so that the ryots had to get water by putting "Korambu" (temporary embankments). The Range Officer informed us that very large scale casualties had occurred that year and it was believed to be due to drought caused by the failure of rains and consequent sinking of the sub-soil water level.

Casuarina in these plantations generally grows quite tall and the soil in general is also an alluvial loam, retentive of nutrients and moisture. Consequently it is evident that an adequate

supply of nutrient and moisture has an important part to play in casuarina growth. A loamy type of soil which is capable of retaining moisture and nutrients, has a great advantage over an inert sand as in Sriharikota and Balukhand. In the latter soil, manuring perhaps becomes necessary say in the form of leaf mould, in order to make the soil normal and retentive of nutrients and moisture. But in case of alluvial loams of Padugais, the soil is normally well supplied with nutrients.

In the Padugai area, the plantations visited were Lalapet, Kulitalai, Sithalavai and Pettavathalai. The Mahadanapuram plantation could not be visited for want of time, but we were told by the Range Officer that there were not many casualties in it.

Lalapet.—In this area it was noticed that on the eastern end there were large scale casualties (about 50–75%) quite a substantial part of which was due to *Trichosporium vesiculosum* (about 20–25%). Representative pits were examined in both the successful and the failed areas, and these are described below :—

Pit 1, in an area with 50% casualties of which 20% is due to *Trichosporium.*

0″–6″ Chocolate coloured, clayey soil with gritty matter (coarse sand).
pH, 7·9, Moisture +.
Effervascence with HCl and H_2O_2 showing presence of carbonates and humus in plenty.

6″–24″ Chocolate brown. Sandy-clay.
pH 8·6, Moisture +.
Effervascence with HCl and H_2O_2 showing presence of carbonates and humus.

24″–46″ Chocolate brown. Sandy-clay.
pH 8·5, Moisture ++.
Carbonates and humus present.

46″–72″ Light brown coloured. Sandy.
Effervascence with HCl but not with H_2O_2 showing presence of carbonates but not humus.
pH 7·9, Moisture ++.
Depth of water-table 8 feet*.

Pit 2, in an area with good casuarina growth, 95% healthy trees, well stocked.

0″–6″ Chocolate brown, sandy loam, loose.
pH 7·8, Moisture +.
Carbonates and humus present.

6″–14″ Brown, loamy sand.
pH 8·6, Moisture +.
Carbonates and humus present.

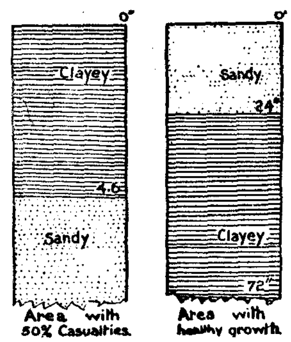
14″–24″ Brown, loamy sand, loose.
pH 8·9, Moisture +.
Carbonates and humus present.

24″–72″ Chocolate coloured clay (or fine-sandy clay) very compact.
pH 8·6, Moisture +++.
Carbonates and humus present.
Depth of water-table 7 feet*.

* The depth of water-table in these plantations was estimated from the level of the flowing water in the adjacent river Kaveri.

It is significant in the above two profiles that the area with casualties has a top clayey layer succeeded by a sandy layer, while the reverse is the case in the area with healthy casuarina in which case a sandy or loamy-sand layer is followed by a clayey layer. It appears that death is due to the fact that in the sub-soil sandy layer in the former, the capillary ascent of moisture is not high enough to bring the water films within the root range of the plants. Due to prolonged drought on account of late rains, water-table went down which increased the depth of the intervening sandy layer between the root range and the water-table. At the same time the top clayey soils got dried up and hardened, and killed the plants. On the other hand in the case of good area, the clay (or sandy clay) below sandy loam, facilitated the easy ascent of capillaries and films of water up to 24″ from ground level, thus supplying the roots located in the well aerated sandy loam layer with moisture. The soil being a loamy type, well supplied with nutrients and retentive of both nutrients and water, helped the healthy growth and survival of the plants. It might be remembered that a top sandy soil is different from a sandy sub-soil in as much as the former contains more humus, thus binding the sand particles and rendering it more retentive of moisture and nutrients along with good aeration. It is also noticed that in the areas where casualties occur the attack of *Trichosporium vesiculosum* is also quite high. Perhaps the attack of fungus accelerates the death.

SOIL PROFILES



Kulitalai.—Like other areas this one also runs west to east with Kaveri river flowing on the north. At the time of the visit of the Central Silviculturist and the Mycologist, last winter, this area was reported to be very badly attacked by *Trichosporium vesiculosum.* However, when the author visited the area it was not found so bad. Lalapet and other areas were much worse than Kulitalai. Range Officer suggested that quite a lot of dead and dying trees had been removed by contractors and perhaps that accounted for the lesser casualties observed. The representative soil profiles for this area are described below :—

Pit 2,	in an area with 30% casualties.
0″–6″	Chocolate brown. Sandy loam. *pH* 7·7, Moisture +. High in carbonates and humus.
6″–27″	Chololate coloured, clayey. *pH* 8·0, Moisture ++. High in carbonates and humus.
27″–37″	Chocolate brown, sandy loam. *pH* 8·7, Moisture ++. Moderate in carbonates and humus.

37″–72″	Yellowish brown. Sandy. *pH* 8·7, Moisture ++. Slight carbonates and humus. Depth of water-table 7 feet.
Pit 3,	between two dead trees attacked by *Trichosporium vesiculosum.*
0″–10″	Chocolate brown. Sandy clay. *pH* 7·5, Moisture +. No carbonates but fair amount of humus.
10″–24″	Chocolate coloured, clayey. *pH* 8·7, Moisture ++. Slight carbonates and lots of humus.
24″–36″	Chocolate brown, sandy loam. *pH* 9·4, Moisture ++. High in carbonate and humus.
36″–72″	Yellowish brown. Sandy. *pH* 8·6, Moisture ++. No carbonate but fair amount of humus. Depth of water-table 7 feet.
Pit 1,	in an area with healthy growth of casuarina.
0″–6″	Chocolate coloured, sandy clay loam. *pH* 8·2, Moisture +. Carbonates and humus present.
6″–18″	Chocolate coloured, sandy clay. *pH* 9·1, Moisture ++. Carbonates and humus present.
18″–36″	Brown coloured, sandy loam. *pH* 8·9, Moisture ++. Carbonates and humus present.
36″–46″	Yellowish brown, loamy sand. *pH* 8·4, Moisture +++.
46″–72″	Bluish grey, sandy soil. *pH* 7·0, Moisture ++++. No carbonates and no humus present. Water-table at 65″.

In the case of above pits, the succession of soil layers is in conformity with that described already for Lalapet. In pits 2 and 3 with partial failure, a top clay or loamy soil is followed by a sub-soil layer of sandy one. This arrangement of soil layers, as already discussed, does not permit moisture to rise to a sufficient height and consequently there is a lack of moisture for casuarina when rains fail and there is a prolonged period of drought.

Also in case of pit 1, with good growth, the top clay loam or loamy soil is succeeded by layer, but the plantation is good due to water-table being high at 5 feet 5 inches. Thus in-between the loamy soil and the water-table, the intervening layer of sand is only 18″. Consequently moisture ascends this small distance up to the loamy soil and then ascends up this latter good textured soil by capillary forces and movement in water films to supply the roots with moisture.

Sithalavai.—In this area the above trends are again repeated as the following will show :—

Pit 2, in an area with casualties (*n.b.* most of the dead trees were removed in auction but nearly 15% still remained at the time of inspection).

0″–8″ Brown coloured. Sandy loam.
pH 8·2, Moisture +.
Carbonates and humus present.

8″–31″ Chocolate coloured. Clayey soil.
pH 8·2, Moisture +.
Carbonates and humus present.

31″–50″ Greyish yellow. Sandy.
pH 8·6, Moisture ++.
No carbonates and no humus.

50″–72″ Greyish yellow. Sandy.
pH 9·3, Moisture +++.
Fair amount of Carbonates and humus.
Depth of water-table, 7 feet.

Pit 1, in an area with good growth.

0″–6″ Brown coloured. Sandy loam.
pH 8·3, Moisture +.
Slight carbonates and humus present.

6″–19″ Brown coloured. Loamy sand.
pH 8·4, Moisture +.
Slight carbonates, moderate humus.

19″–36″ Brown coloured. Sandy loam.
pH 8·4, Moisture ++.
High carbonates, moderate humus.

36″–72″ Chocolate coloured. Clayey soil.
pH 8·2, Moisture +++.
High carbonates and high humus.
Depth of water-table 7 feet.

From the above it is quite evident that in the case of the healthy plantation a sandy loam top layer of soil is followed by a clayey sub-soil layer, while in the case of the area with casualties the reverse is the case, i.e. the sandy layer of soil is at the bottom thus causing difficulty regarding the ascent of water during drought and consequent hardening of top clayey layer on drying.

Balukhand (Puri) Plantations.—Balukhand range consisting of 14 compartments is situated near Puri in Orissa. The soil is sandy like Sriharikota and the water-table is also high (about 6–8 feet from the surface). Unlike Sriharikota, however, most of the plantations are in second rotation. It has been reported that in the first rotation, casuarina appeared to have done well in most of the areas, but in the second and subsequent rotations there were casualties in some areas and poor and stunted growth in others. It might be pointed out that the rotation here is 20 years and not 7 years as in Sriharikota. The first plantation in Balukhand was put in 1916. It is reported that the actual trouble regarding casualties started after the Sur Lake Cut in 1931. Some officers suggested that the Sur Lake Cut was responsible for the lowering of

the water-table, on account of which casuarina plants started dying (1, 2). With this background the author started his soil investigation in the Balukhand range. A further observation of significance, made by B. K. Bakshi was that there is no attack of *Trichosporium vesiculosum* in this area, though attacks of other fungi and particularly that of *Ganoderma lucidum* was there. The latter, however, could be controlled if the period of rotation is reduced to less than 18 years (3).

The soil investigations reported here are based on the following observations :—

(i) There were areas with healthy growth of casuarina, side by side with failures.

(ii) There were certain areas with casualties in patches only.

(iii) Some of the areas did not have much casualties but the trees had stunted growth. (*n.b.* The areas with stunted growth did not necessarily have casualties).

(iv) There were areas which had both stunted growth and casualties.

(v) Most of the areas with casualties had also grown up trees.

(vi) There were areas near the Sur Lake Cut both with good growth as well as heavy casualties. This refutes to a large extent the theory that Sur Lake Cut is the cause of failure.

Some of the soil profiles representing the above cases are discussed below. Healthy areas in the vicinity of the unhealthy ones are described side by side to clarify the differences.

Cpts. 2 & 4

Pit 2, in 1935 plantation (2nd rotation), area with healthy growth and well stocked.

0″–8″ Yellowish grey coloured. Sandy.
Slight amount of organic matter present.
pH 6·0, Moisture ++.

8″–21″ Greyish yellow coloured. Sandy.
No humus present.
pH 6·0, Moisture +++.

21″–36″ Greyish yellow coloured. Sandy.
pH 6·2, Moisture +++.

36″–72″ Deep yellow coloured. Sandy.
pH 6·0, Moisture +++.
Ground water-level 7 feet.

Pit 1, Area with 70% blank and casualties (but this year's mortality was about 10% only).

0″–7″ Yellowish grey coloured. Sandy.
Slight amount of organic matter present.
pH 6·4, Moisture ++.

7″–20″ Yellowish grey. Sandy.
pH 6·2, Moisture +++.

20″–34″ Greyish yellow. Sandy.
pH 6·7, Moisture +++.

(1) NICHOLSON, J. W. (1946), " Note on casuarina ", *Silvicultural Conference*, 1946, Item No. 14.
(2) SHARMA, A. R. (1946), " A note on casuarina plantation in Puri Division, Orissa ", *Loc. Cit.*
(3) BAKSHI, B. K. (1946), " Mortality of *Casuarina equisetifolia* Forst. " *Indian Forester* 77 (4), 269–76.

34″–72″ Deep yellow. Sandy.
pH 6·5, Moisture +++.
Water-table about 7–8 feet.

(*n.b.* Monsoon broke on June 15, 1950, but rainfall is below normal).

In the two soil profiles described above, the soil appears to be more or less the same as the *pH* value and even water-table does not differ. Yet one area has good growth while there are casualties (in a small patch though) in the other. It has, however, to be pointed out that a large part of these compartments (Cpts. 2–4) have good growth, though failures occur in small patches. Just at present it is not possible to state the cause of these failures definitely. It may be that in initial stages due to inadequate watering, certain patches had a set back and later on plants died during the periods of drought.

Cpts. 10 & 11.—In this locality all possible cases were met with : namely areas with good growth, failed areas, areas with stunted growth and areas with high water-table. A high water-table may cause water logging during rains on account of which growth may be arrested. It is rather interesting that both, areas containing good growth and failed areas, occurred near Sur Lake Cut, which was stated to be responsible for large scale failures. Profiles representing all the cases are described below.

Pit 1, in an area with stunted growth and 30% casualties. Water-table very high.

0″–6″ Yellowish grey coloured. Sandy.
Slight organic matter present.
pH 6·1, Moisture +.
6″–19″ Yellow coloured. Sandy.
pH 6·1, Moisture ++.
19″–39″ Banded yellow and yellowish grey.
Sandy texture.
pH 6·1, Moisture +++.

39″–72″ Greyish yellow. Sandy.
pH 5·8, Moisture +++.
Water-table in this horizon at 50″.
Water-table at 4′ 2″.

Pit 2, in 1940 plantation, area with good growth adjoining the above.

0″–10″ Yellowish grey. Sandy.
Slight organic matter present.
pH 6·3, Moisture +.

10″–20″ Streaked yellow and grey. Sandy.
pH 6·4, Moisture ++.

20″–47″ Deep yellow, mottled with brown.
Loamy sand.
pH 6·0, Moisture +++.

47″–72″ Greyish yellow. Sandy.
pH 6·2, Moisture +++.
Water-table about 5 feet 6 inches.

Pit 3, in 1936 plantation, area with 80% casualties but with no stunted growth ; the height of surviving trees being about 30 feet.

0″–6″	Yellowish grey. Sandy. Very slight organic matter present. *pH* 6·0, Moisture +.
6″–16″	Greyish light yellow. Sandy. *pH* 6·3, Moisture ++.
16″–36″	Deep yellow. Sandy. *pH* 6·0, Moisture ++.
36″–72″	Yellow coloured Sandy soil, Texture coarser than above. *pH* 6·0, Moisture ++. Water-table 9 feet 6 inches.
Pit 4,	1936 plantation, West side of Sur Lake Cut ; an area with good growth.
0″–9″	Yellowish grey. Sandy. Slight organic matter present. *pH* 6·2, Moisture +.
9″–24″	Greyish light yellow. Sandy. *pH* 6·4, Moisture ++.
24″–44″	Greyish yellow streaked with grey. Loamy sand. *pH* 6·6, Moisture ++.
44″–72″	Yellow, streaked with brown and mottled with reddish brown. Loamy sand. *pH* 6·6, Moisture +++. Water-table at 8 feet.
Pit 5,	in 1944 plantation raised on the failure of 1936, regeneration area. West side of Sur Lake Cut. An area with stunted growth and 30% casualties.
0″–7″	Greyish yellow. Sandy. Slight organic matter present. *pH* 5·9, Moisture +.
7″–18″	Yellow, banded with greyish yellow. Sandy texture. *pH* 6·3, Moisture ++.
18″–36″	Yellow coloured. Sandy. *pH* 6·4, Moisture ++.
36″–72″	Yellow, banded with greyish yellow. Sandy texture. Very slight organic matter present. *pH* 6·6, Moisture ++. Water-table 6 feet 10 inches.

Note.—Organic matter has been washed from top layer to bottom layer, thus impoverishing the former.

Cpts. 12–14.—These compartments are to the East of the Sur Lake Cut. Both good growth and failures occur here also, as the profiles described below will show. It may be noticed that the Pits 4 and 5 were on the West side of the Sur Lake Cut, in corresponding positions.

Pit 1, in 1942 plantation, area with poor growth and 70% casualties. Average height of trees 10–15 feet.

0″–10″ Light-yellow. Sandy.
Very slight organic matter present.
pH 6·3, Moisture +.

10″–26″ Yellow coloured. Sandy.
pH 6·2, Moisture ++.

26″–46″ Deep yellow streaked with slight brown and mottled with brown.
Sandy texture.
pH 6·5, Moisture ++.

46″–72″ Chocolate coloured, Loamy sand.
Fairly high in organic matter.
pH 6·4, Moisture +++.
Water-table 7–8 feet.

Note.—It may be noted that organic matter has been washed from top layer to bottom layer, thus impoverishing the former.

Pit 2, in 1943 plantation, area with good growth, Average Height of trees 45–50 feet.

0″–12″ Greyish yellow. Sandy.
Slight organic matter present.
pH 6·1, Moisture ++.

12″–28″ Yellow coloured. Sandy.
pH 6·3, Moisture ++.

28″–48″ Deep yellow, streaked with yellow, and mottled with brown.
Sandy texture (tending to loamy sand).
pH 6·2, Moisture +++.

48″–72″ Deep yellow, mottled with brown.
Loamy sand texture.
pH 6·3, Moisture +++.
Depth of water-table 9 feet 7 inches.

Poor growth of casuarina as related to soil conditions.—Stunted growth of casuarina in certain areas is due mostly to an inadequate development of the roots. Two photographs given below show the stunted trees with their badly developed roots. This under-development may be due to the following causes :—

(1) Where water-table is too high [as cpt. (10, 11) Pit. 1], the roots are unable to develop in the water-logged sub-soil.

(2) In the initial stages of planting, due to insufficient water and organic matter (nutrients) in the soil, the root development may be restricted and consequently the plant would have a stunted growth.

(3) In some localities, most of the nutrients and organic matter may be washed down from the top soil where the roots occur, into the sub-soil which is much below the root zone [see cpt. (10, 11) Pit. 5 and cpt. (12, 14) Pit. 1]. Thus in the top soil deficient in nutrients, the development of the roots and the plant is poor.

(4) Along with poor root development, the ascent of moisture from the water-table may be inadequate due to the peculiar nature of the sub-soil (to be discussed later). In this case also there will be casualties due to sub-soil drought.

Water-table and growth of casuarina.—Even though moisture has a great part to play in the growth of casuarina, mere location of the water-table does not give us a correct idea of the water supply to the plants. The ascent of water from the water-table depends, to a considerable extent, on the texture of the soil and the relative position in the soil profile of different layers with different textures. This determines the availability of moisture to the plant along with adequate aeration. A water-table too high (say about 4 feet in June) handicaps the plant, due to water-logging and lack of aeration, even though moisture is available in plenty. Perhaps the most favourable condition would be a water-table at a depth of about 8–9 feet with soil layer of a moderate texture, sandy-loam or sandy-clay-loam, above it and with top layer of sand or loamy sand. This will allow upward movement of moisture by film action leaving air spaces in-between to allow proper aeration. To consider water-table alone, without regard to the form of soil profile and soil texture, may be misleading.

As already mentioned, previous observations have been made ascribing the mortality in casuarina in Balukhand range to Sur Lake Cut and consequent lowering of the water-table. Observations made by the author do not, however, appear to support this view. In compartments 10 and 11 and also in cpts. 12 and 14 of Balukhand, there are areas bordering the Sur Lake Cut where there is stunted growth and casualties and also areas with good growth. Examples of poor growth are found in cpt. (10, 11) near Pit 3, cpt. (10, 11) near Pit 5 and cpt. (12, 14) near Pit 1 and that of good growth are cpt. (10, 11) near Pit 2, cpt. (10, 11) near Pit 5, and cpt (12, 14) near Pit 2. The respective depths of water-table in these places are revealing.

Area with	*Respective depths of water-table*		
Poor growth or/and casualties	(i) 9′ 3″	(ii) 6′ 10″	(iii) 8′ 7″
Good growth and well stocked	(i) 6′ 0″	(ii) 8′ 0″	(iii) 9′ 7″

From the above we see that there is poor growth in area having water-table between 6′ 10″–9′ 3″ and also good growth in ares with water-table between 6′ 0″–9′ 7″. These are just a few instances of adjacent localities out of many, which were chosen near Sur Lake Cut in Balukhand.

A table is given below which shows more clearly how any conclusion drawn on the basis of the depth of water-table alone is likely to be misleading.

Area with good casuarina growth			*Area with casualties*		
Area	Location	Depth of W.T.	Casualties%	Location	Depth of W.T.
Sriharikota	S (R) 2	10 feet	80%	S (R) 1	10 feet
	S (C) 1	10 feet	80%	S (C) 2	8·0 feet
Balukhand	(12, 14) 2	9·7 feet	80%	(10, 11) 3	8·3 feet
	(10, 11) 4	8·0 feet	70%	(12, 14) 2	8·7 feet
	(2, 4) 2	7·0 feet	70%	(2, 4) 1	7·5 feet
	(10, 11) 2	6·0 feet	70% & S.G.	(10, 11) 5	6·8 feet
			30% & S.G.	(10, 11) 1	4·3 feet
Padugais ..	M (S) 1	7·0 feet	50%	M (L) 1	8·0 feet
	M (L) 2	7·0 feet	50%	M (K) 2	7·0 feet
	M (K) 1	5·0 feet	between two trees with T.S.	M (K) 2	7·0 feet
			70% & between two dead trees	M (S) 2	7·0 feet

Note.—S.G. = Stunted Growth. Ts = *Trichosporium*.

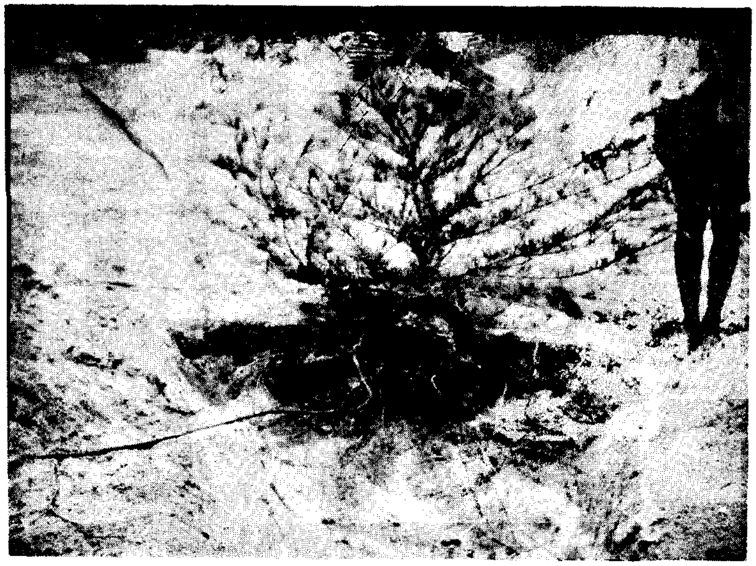


PHOTO 4

A stunted casuarina tree, only 3 feet 8 inches high (age 6 years) is shown. Roots go only 2 feet 4 inches deep, below surface. Laterally the roots go 13 feet from the base of the tree, at a maximum.

Locality :—Balukhand (Puri), Cpt. 11, Section 9.

Date : 9-7-50.

PHOTO 5

A stunted tree 6 feet 2 inches high is shown. Tap root is 3 feet 5 inches below the surface.

Locality :—Balukhand (Puri), Cpt. 11.

Date : 9-7-50.

It is seen that the depth of the water-table varies from about 5·5 to 10 feet both for good areas, as well as areas with casualties. The only notable point, however, is that if the water-table is very high (about 4 feet in June) then there is insufficient root development due to water-logging of the sub-soil and plants have consequently stunted growth.

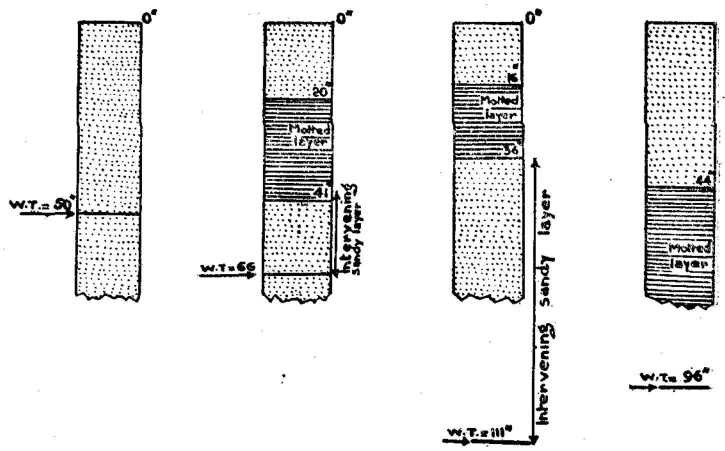
That we cannot take water-table alone as an index of good growth is illustrated in a few observations given below. Going from North to South in cpts. 12 and 14, more or less parallel to the Sur Lake Cut (which was west of the line), the following observations were made :—

Depth of water-table ..	10′ 4″	9′ 7″	8′ 7″	8′ 7″
Average height of trees	40′ 45″	25′	12′	7′ 8″
Average girth ..	15″	13″	7″	7″

With water-table getting higher, one would have expected better growth due to greater availability of moisture, but it is the reverse. It, however, does not follow that lower water-table is an advantage, because this is not confirmed in other observations. But it does show that water-table cannot be taken as a single value factor for determining either the growth of casuarina or its survival. We have to consider the sub-soil factors also. One of these factors is the proximity of a moisture retentive soil layer near the water-table so that water is able to rise up by film action to supply moisture to casuarina roots, without impeding soil aeration.

Soil layers as related to water-table and casuarina growth.—It has been seen in many cases that a moisture retentive soil layer which is not altogether sandy, but is either sandy-loam or loamy-sand in texture has a great part to play in a sandy area like Balukhand. Such a layer will allow a better ascent of moisture from the water-table and the soil is itself retentive of moisture. It is usually yellow coloured with brown mottling which indicates rise and fall of water-table. This rise and fall, incidentally, may help in aeration of the roots while at the same time supplying adequate moisture. Four typical profiles are discussed below to illustrate the point. These were all taken in Cpts. 10 and 11 of Balukhand.

TYPICAL SOIL PROFILES



	Pit 1		Pit 2		Pit 3		Pit 4
Water table	4′ 2″ (or 50″)		5′ 6″ (or 66″)		9′ 3″ (or 111″)		8′ 0″ (or 96″)
Nature of Casuarina Growth	Stunted growth. 30 % Casualties		Good growth. Fully Stocked		Poor growth. 80% Casualties		Good growth. Fully Stocked
Av. Ht. of Trees.	1′–3′		45′–50′		30′ nearly		60′–65′

The above cases indicate how the water-table and the morphology of the soil profile together influence the root development and growth of casuarina. All the four cases are discussed below to make this point clear.

Pit 1. Due to high water-table, namely 4′ 2″ only, though plants receive plenty of moisture, yet they are stunted because water-logged soil does not permit of adequate root expansion. This limits plant growth and make them stunted.

Pit 2. Here the mottled layer of soil, which is retentive of moisture, lies over coarse sandy layer. In such a case if the water-table had been low, there would be failure due to inadequate ascent of moisture (as in Pit 3). But the water-table here is at 66″ only, so that there is only 19″ of coarse sandy layer (47″–66″) through which the capillary water has to rise in order to meet the mottled layer. This it is able to do. Capillary currents thus travel this 19″ of sandy layer and reach the mottled layer where it rises by film action. Hence there is good moisture supply with proper aeration to roots and there is good growth.

Pit 3. Here also the mottled layer of soil lies over coarse sand as in Pit 2 but water-table is too low (at 111″), so that there is a gap of 77″ coarse sandy layer between the mottled layer and the water-table. Over this gap, water cannot rise by capillary action to reach the tree roots. Plants consequently die of drought and there are 80% casualties.

Pit 4. This is an ideal set of condition where the mottled layer (moisture retentive layer) extends up to the water-table. Water rises up this layer, by film action and this ensures water supply to roots without affecting aeration. The top 44″ of sandy layer contains the roots, which also extends down into the moisture retentive mottled layer of soil. Consequently in this locality there is good root development and therefore best growth of the plants (Average height 45′–50′).

Comparison of conditions in Pit 3 and Pit 4 shows, how with similar depths of water-table, the arrangement of soil layers make all the differences, whereas a comparison of Pit 2 table influences the growth. Both the factors have therefore to be considered. These cases may be compared with those discussed under Padugai plantations.

pH of soil and casuarina growth.—*pH* of soil does not appear to have much correlation with casuarina growth or casualties therein. As a matter of theoretical interest it may be mentioned that an admixture of leaf litter (needles) lowers the *pH* to acidic side while if there is an admixture of sea shells the *pH* is raised to alkaline side. But there are good and poor areas over all ranges of *pH* met with in the localities under investigation. One important point may, however, be mentioned in this connection, namely, that casuarina appears to tolerate a very highly alkaline condition of soil and has been found to exist in some areas in Padugai with soil *pH* as high as 9·0 to 9·5. This makes it a suitable species for planting in saline and alkaline soils such as Usar and Kallar lands. Since its leaf litter makes the soil acidic or neutralises the alkalinity, it may prove of value in the reclamation of these alkaline lands.

Conclusions.—The main requirements for the healthy growth of casuarina from the soil point of view are (1) an adequate supply of moisture (but no water-logging) and (ii) an adequate supply of nutrients particularly nitrogen drawn from say, natural, humus or manure (leaf litter). These are particularly important in the initial stages of development, of casuarina growth, because they induce a good root development, which is necessary for the healthy and the tall growth of the tree. Water-logging and very high water-table (say about 4 feet in June) are likely causes for stunted growth due to poor root development. Shallow root

development in the initial stages can also be due to insufficient moisture and nutrients, especially nitrogen. In areas which are sandy such as Sriharikota and Balukhand, this has to be particularly kept in mind.

As regards the suitability of the soil for casuarina, it is generally seen that a moisture retentive soil layer of a closer texture than sand, in the proximity of the water-table, with a sandy layer on top, is helpful to casuarina. When reverse is the case, i.e., a coarse sandy layer occurs below the loamy top soil, in localities with low water-table, there is inadequate ascent of moisture, leading to soil drought and consequent plant casualties. In the latter cases the plantation may keep on doing well during favourable monsoon but when the monsoon fails or when there is a long stretch of years of drought on account of which water-table goes down, there is a likely danger of large scale casualties in casuarina plantations (see figs. on p. 15 and p. 26). Drought condition can also be caused due to another sub-soil factor. It is seen in some areas especially in the sandy localities of Sriharikota and Balukhand that the sub-soil layer is sometimes a very coarse grained sand, i.e., coarser than normal top sandy layer. Ascent of moisture is hard in such a layer of extra coarse sand and creates soil drought in upper horizons thus causing casualties or stunted growth. This top soil drought is also detrimental to the development of root nodules which are of such vital importance in sandy soils.

Root nodules play an important role in growth of casuarina in sandy soils. These soils being poor in humus have to depend mainly on the fixation of atmospheric nitrogen by root nodules as the only source of N-supply. For the healthy development of these nodules, the top layer of soil (nearly 2 feet) in which they mostly occur, should not become too dry. Strips of plantations by the sea coast have a great advantage in this respect since sea breeze, with plenty of sea-water spray, blows past the base of the trees and keeps the top soil moist. Away from the sea, the top soil gets dry, thus impeding the noduler development. In consequence the plants in the sterile sandy tracts get stunted or die due to N-deficiency and lack of moisture, even though the water-table may not be very different. In the alluvial loams and clays such as in Padugais, the importance of root nodules is not so great as in the sands of Sriharikota and Balukhand (Puri). The former are well supplied with humus from which the plants can draw their supply of nitrogen.

pH of soil does not appear to have much correlation with casuarina growth or casualties therein. As a matter of theoretical interest it may be mentioned that where there is an admixture of leaf litter, the pH is lowered to acidic side, while if there is an admixture of sea shells, the pH is raised to the alkaline side. But there are good and poor areas over all ranges of pH met with in the localities investigated. One important point, however, is that casuarina tolerates highly alkaline soils, as having pH as high as $9 \cdot 0$ to $9 \cdot 5$. This combined with the acidic nature of its humus which has the power of neutralising alkalinity, can make it a suitable species for planting in alkaline and saline lands with a view to reclaiming them for cultivation.

As regards the correlation of soil conditions to the attack of *Trichosporium vesiculosum*, no correlation has so far been found between the existence of this fungus and such field determinations as pH, texture of soil and moisture conditions, etc., but the analysis of soils are in progress and therefore no definite conclusions can be drawn at this stage. The fact, however remains that this fungus is entirely non-existing in Balukhand (Puri) plantations, even in areas with worst casualties.

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THE CONTROL OF THE INDIAN BOOKWORM BEETLE, *GASTRALLUS INDICUS* REITTER (COLEOPTERA: ANOBIIDÆ), BY THE HEAT TREATMENT, TOGETHER WITH OBSERVATIONS ON THE POST-TREATMENT VIABILITY OF THE LARVÆ

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(With 1 Plate and 3 Tables)

I.—INTRODUCTION

(*a*) *General.*—The recent finding of a heavy infection of the Indian bookworm beetle*, *Gastrallus indicus* Reitter (Insecta: Coleoptera: family Anobiidæ), in nearly 800 library cards of the Central Library of the Forest Research Institute, Dehra Dun, led us to carry out certain experiments with a view to obtain precise data for determining the minimum effective temperature and duration required for destroying the infection by the dry-heat treatment. This treatment is a simple and easily available method of killing an existing infection, but the minimum effective temperature and duration are not known. Exposure to needlessly high temperatures and for an unnecessarily long duration would cause avoidable injury to books and other materials. Beeson (1941, p. 877), evidently from literature, gave the following recommendations without stating the duration of the treatment:—"If damage is limited, bake the books in an oven at a temperature of over 130°F. [= *ca.* 50·6°C.] or expose the covers to direct heat of the sun". As will be seen from the experiments discussed below, it is evident first, that temperatures appreciably higher than 50·6°C. are required to obtain effective kills, and secondly, that the duration of the treatment is an important factor in achieving success.

(*b*) *Known records of infection of the bookworm* Gastrallus indicus.—This bookworm has been hitherto recorded from India and Burma. The Annual Report for 1920–21 of the Department of Agriculture in Burma records a heavy attack of books in a library in Mandalay, Burma. Husain (1929–30) mentions serious damage to revenue records in the Punjab in India. There are records in the Forest Entomologist's files of serious damage done by this beetle to (*i*) books in the Central Library of the Forest Research Institute, Dehra Dun in November 1937, and to carrier cards in September 1950; (*ii*) to "the binding and papers of the documents" in the Government of India's Imperial Record Department, New Delhi, in September 1939 and April 1942; and (*iii*) to old palm-leaf records in Trivandrum (Travancore, South India).

(*c*) *Other bookworms.*—Among other species of Anobiidæ bookworms are the following:—*Gastrallus laticollis* Pic. has been recorded by Kalshoven (1930) from Indonesia (Dutch East Indies); Swezey (1933, p. 238), found it in the Hawaii Islands in cardboards from India (May 1930). Among the other bookworms recorded from Indonesia are the common species *Lasioderma serricorne* F. and the rarer *Catorama herbarium* Gorh. *Sitodrepa panicea* L. has been recorded as a bookworm in India and Indonesia but there are grounds for suspicion that many records of this species may be due to misidentification of *Gastrallus indicus* (*vide* Gardner, 1937; Kalshoven, 1938). *Ptilinus testaceus* Pic. has been recorded by Pic. (1936) as boring into books in Malaya.

* This bookworm was previously confused with another species, namely, *Sitodrepa panicea* L., which also is an Anobiid beetle.

Finally, Kalshoven (1938) records that the dry-wood termite, *Cryptotermes* sp. (Isoptera) damages books in Indonesia by boring.

(*d*) *Nature of damage, etc., by* Gastrallus indicus.—The larva of *Gastrallus indicus* bores through cardboards, paper bundles, etc., making parallel-sided galleries about 1–1·5 mm. wide and running in different directions (Pl. 1, Figs. 1 and 2). The galleries are usually filled with a granular, dark brown dust (Pl. 1, Fig. 3) composed of rather flat irregular-shaped grains of excreta. When the infected material is tapped, this dust freely falls out. Besides the galleries, portions of which may be visible externally, there are numerous small circular "shot-holes" usually about 1 mm. or less in diameter ; these are the emergence holes through which the adult beetle emerges after transformation from the larva and pupa. The emerging beetles usually make a straight perforation running through the thickness of the book from one side to the other. A heavily infected book is riddled with such holes and galleries, this being usually the result of repeated and prolonged infection over a number of years. A heavily infected 30 square inch cardboard or book board may have as many as 55 or 60 emergence holes and about an equal number of superficially visible galleries. The galleries usually contain larvæ in various stages of development, pupæ and immature beetles.

The adult beetle (Pl. 1, Fig. 4*b*) is a small, slender, testaceous brown (paler and somewhat ochraceous when immature) insect about 2–3 mm. long and 1 mm. wide ; it has smooth, parallel sides.

The mature larva (Pl. 1, Fig. 4*a*), which is about 3–4 mm. long, has a stout, white, semi-cylindrical and crescent-shaped body with the thorax comparatively swollen ; it very much resembles the larvæ of powder-post-beetles or Bostrichidæ. There are 3 pairs of tiny thoracic legs. A brief description of the larva has been given by Gardner (1937, p. 135).

The life-history is not known.

(*e*) *Acknowledgments.*—We are indebted to Dr. K. R. Nair the Statistician, Forest Research Institute, Dehra Dun, for randomizing the experimental cards ; to Shri M. A. Rehman, Officer-in-Charge, Wood Seasoning Branch, for exposing the cards to various temperatures in the hot-air thermostats ; and to Shri Jai Kishen, Assistant Wood Seasoning Officer, for calculating the humidities in the thermostats during exposure.

II.—MATERIAL AND METHODS (Table 1)

The infected cards in the Central Library of the Forest Research Institute, Dehra Dun, were about $11 \cdot 5 \times 16 \cdot 5$ cm. in length and width, and about 0·2 cm. in thickness. They had a brown cardboard core, with thin white paper pasted all round on the outside presumably with flour-paste. Out of the 392 infected cards in the first lot, 12 were "heavily" infected, the remaining 380 "moderately" infected. The infection consisted of living larvæ of all stages from the youngest to mature ones and *dead* and dry adult beetles, the latter evidently representing adults of the earlier generations which were unable to emerge from the cards. The degree of infestation may be judged from the data in Table 1 which shows the number of larvæ and dead beetles obtained from 103 "moderately" infected and 3 "heavily" infected cards, the average being 2 insects per card for the former and 10·7 for the latter category. If the dead beetles are ignored and the active larvæ alone counted, the degree of infestation works out at 1·6 larvæ per card for the moderately infected and 8·7 larvæ for the heavily infected category.

The moderately infected cards were utilized for the heat experiments, and on each of the 380 available cards a serial number (from 5 to 384) was punched. The cards were then statistically randomized and subjected to the following 20 treatments at 6 temperatures ranging from 50° to 100°C. and for 3–4 periods of duration (from 1 to 4 hours) :—

(i) 50°C. for 1, 2, 3 and 4 hours.
(ii) 55°C. for 1, 2, 3 and 4 hours.

(iii) 60°C. for 1, 2 and 3 hours.
(iv) 70°C. for 1, 2 and 3 hours.
(v) 80°C. for 1, 2 and 3 hours.
(vi) 100°C. for 1, 2 and 3 hours.

The randomized distribution of the 100 experimental cards in the 20 experiments is shown in Table 2. In each treatment 5 cards were exposed in electrically controlled hot-air thermostats with a temperature regulation accurate up to $\pm$ 0·5°C. Three to four days* after exposure, the cards were examined and the larval and beetle population of each card recorded under the following 3 categories :—

(*a*) Larvæ alive. (Active. When disturbed with a needle, reacting strongly by moving the legs and body vigorously).

(*b*) Larvæ half-dead. (Alive but dull. Reacting very slowly when disturbed).

(*c*) Adult beetles, *dead*. (Only dead beetles were found. No live ones were met with even in the untreated cards).

The extracted insects were put in glass tubes and kept under observation for a few days more.

The calculated relative humidities during the experimental period of exposure of the cards in the thermostats at the various temperatures were approximately as follows :—At 50°C., 13% ; at 55°C., 11% ; at 60°C., 8% ; and at 80°–100°C., negligible. The corresponding room humidities varied from 77% to 86%. It is believed that the low humidities in the thermostats were reached during the first few minutes to half-hour of exposure and remained constant thereafter, there being but little moisture in the cards. We may consequently assume for practical purposes that the relative humidities inside the thermostats throughout the period of exposure were extremely low (0–13%).

TABLE 1.—Degree of infestation (number of insects per card) of *Gastrallus indicus* in library cards in the Central Library, Forest Research Institute, Dehra Dun, in second week of October, 1950

Item	No. of larvæ found			No. of adult beetles (all dead) found	Total of larvæ and adults
	Young	Mature	Total		
	(A)—Moderately infected cards (103 cards, in 21 lots of 3–5 cards in each lot)				
Total (of 103)	119	49	168	34	202
Range (in each lot of 3–5 cards) ..	0–12	0–6	0–16	0–5	2–18
MEAN (in 1 card)	1·2	0·5	1·6	0·3	2·0
	(B)—Heavily infected cards (3 cards only)				
Total (of 3)	..	..	26	6	32
Range (in 3 cards) ..	..	..	3–16	2–4	5–20
(MEAN in 1 card) ..	..	..	8·7	2	10·7

* This interval of 3–4 days was allowed to elapse between the moment of treatment and that of examination of cards in order to give time for recovery to those larvae which might have suffered temporary heat-stupor as a result of treatment.

III.—EXPERIMENTAL RESULTS (Tables 2–3)

(*a*) *General results*

The effect of heat treatment on the larvæ alone is considered here. Even in the unexposed cards no live beetles, but only dead and dry beetles (presumably the remnants of an earlier generation which had failed to emerge), were found, and for this reason, it is not possible to judge the effect of the treatment on the adults. The results of exposure at various temperatures may now be discussed in detail (Tables 2–3).

TABLE 2.—Results of 20 experiments on the library cards (each *circa* 11·5 × 16·5 × 0·2 cm.), infected by the bookworm *Gastrallus indicus*, and exposed to "dry heat" treatment, in an air oven at 6 temperatures from 50°–100°C. and for varying periods of 1–4 hours.

Abbreviations.—A., adult ; L., larva.

Card No.	Result of examination after treatment	
	After 3–4 days	On 5th and subsequent days
1	2	3
	Expt. No. 1.—50°C. for 1 hour	
104	3 L. alive	L. died on 12th day.
140	1 L. alive	Do.
174	1 L. alive	Do.
183	1 L. alive	Do.
347	4 L. alive	Do.
SUMMARY	All larvæ alive	Larvæ died on 12th day, probably due to starvation.
	Expt. No. 2.—50°C. for 2 hours	
86	3 L. half-dead	L. died on 6th day.
157	3 L. half-dead	Do.
249	2 L. half-dead	Do.
378	2 L. half-dead ; 1 A. dead	Do.
384	2 L. half-dead	Do.
SUMMARY	All larvæ half-dead	Half-dead larvæ died on 6th day.

(*contd.*)

TABLE 2—(*contd.*)

Card No. 1	Result of examination after treatment: After 3–4 days 2	Result of examination after treatment: On 5th and subsequent days 3
	Expt. No. 3.—50°C. for 3 hours	
38	A few dry elytra of A.	..
244	2 L. half-dead	L. died on 6th day.
282	1 L. dead ; 2 A. dead	..
329	3 L. half-dead	L. died on 6th day.
358	3 L. half-dead	Do.
SUMMARY	One larva dead ; remaining ones only half-dead.	Half-dead larvæ died on 6th day.
	Expt. No. 4.—50°C. for 4 hours	
44	Nil	..
72	2 L. half-dead	L. died on 6th day.
117	Nil	..
286	3 L. dead ; 1 A. dead	..
349	2 L. dead ; 1 A. dead	..
SUMMARY	Many larvæ dead, but some still alive (half-dead).	Half-dead larvæ died on 6th day.
	Expt. No. 5.—55°C. for 1 hour	
306	7 L. alive ; 1 A. dead	L. died on 9th day.
161	3 L. alive	Do.
39	1 L. alive	Do.
54	Nil	..
154	3 L. dead	..
SUMMARY	Most larvæ alive and active ; a few dead.	The active larvæ died on 9th day, probably by starvation.

(*contd.*)

TABLE 2—(*contd.*)

Card No. 1	Result of examination after treatment: After 3–4 days 2	On 5th and subsequent days 3
	Expt. No. 6.—55°C. for 2 hours	
68	4 L. half-dead	L. died on 5th day.
124	7 L. half-dead	Do.
139	Nil	..
359	3 L. half-dead	L. died on 5th day.
367	1 A. dead	..
SUMMARY	All larvæ half-dead	Half-dead larvæ died on 5th day.
	Expt. No. 7.—55°C. for 3 hours	
126	2 L. half-dead	L. died on 5th day.
142	1 L. half-dead	Do.
275	1 L. dead ; 1 L. half-dead ..	Do.
277	3 L. half-dead	Do.
338	1 L. dead ; 1 L. half-dead ..	Do.
SUMMARY	Most larvæ half-dead ; a few dead ..	Half-dead larvæ died on 5th day.
	Expt. No. 8.—55°C. for 4 hours	
11	Nil	..
217	1 L. dead	..
343	1 L. half-dead and dry	..
313	1 L. half-dead	L. died on 5th day.
29	1 L. dead ; 1 A. dead	..
SUMMARY	Some half-dead ; others dead ..	Half-dead larva died on 5th day.
	Expt. No. 9.—60°C for 1 hour	
74	2 L. half-dead	Crushed accidentally.
194	2 L. dead	..
260	Nil	..
283	1 L. dead ; 1 A. dead	..
293	1 L. half-dead	?
SUMMARY	Some larvæ half-dead ; others dead ..	..

TABLE 2—(*contd.*)

Card No. 1	Result of examination after treatment: After 3–4 days 2	On 5th and subsequent days 3
	Expt. No. 10.—60°C. for 2 hours	
20	Nil	..
149	1 L. dead ; 1 A. dead	..
163	1 L. dead	..
211	1 L. dead	..
264	2 L. dead	..
SUMMARY	All larvæ dead	..
	Expt. No. 11.—60°C. for 3 hours	
83	1 L. dead ; 1 A. dead	..
114	3 L. dead	..
151	Nil	..
234	3 L. dead ; 2 A. dead	..
259	2 L. dead	..
SUMMARY	All larvæ dead	..
	Expt. No. 12.—70°C. for 1 hour	
24	3 L. dead	..
57	Nil	..
82	2 L. dead ; 3 A. dead	..
184	Nil	..
224	Nil	..
SUMMARY	All larvæ dead	..
	Expt. No. 13.—70°C. for 2 hours	
131	2 L. dead ; 1 A. dead	..
176	Nil	..
219	Nil	..
301	2 L. dead ; 2 A. dead	..
346	2 L. dead	..
SUMMARY	All larvæ dead	..

(*contd.*)

TABLE 2—(*contd.*)

Card No. 1	Result of examination after treatment	
	After 3–4 days 2	On 5th and subsequent days 3
	Expt. No. 14.—70°C. for 3 hours	
116	Nil	..
261	3 L. dead	..
325	3 L. dead ; 3 A. dead	..
330	4 L. dead	..
352	2 L. dead ; 2 A. dead	..
SUMMARY	All larvæ dead	..
	Expt. No. 15.—80°C. for 1 hour	
150	1 A. dead	..
202	5 L. dead	..
248	Nil	..
287	Nil	..
294	1 L. half-dead (crushed accidentally) ; 1 A. dead.	..
SUMMARY	One larva half-dead ; all others dead ..	..
	Expt. No. 16.—80°C. for 2 hours	
137	Nil	..
193	Nil	..
227	3 L. dead ; 2 A. dead	..
320	2 L. dead	..
381	1 L. dead	..
SUMMARY	All larvæ dead	..
	Expt. No. 17.—80°C. for 3 hours	
21	1 A. dead	..
78	2 L. dead ; 1 A. dead	..
215	2 L. dead	..
263	Nil	..
276	Nil	..
SUMMARY	All larvæ dead	..

(*contd.*)

TABLE 2—(*concld.*)

Card No.	Result of examination after treatment	
	After 3–4 days	On 5th and subsequent days
1	2	3
	Expt. No. 18.—100° C. for 1 hour	
14	Nil	..
55	Nil	..
66	2 A. dead	..
89	Nil	..
225	Nil	..
SUMMARY	No larvæ found	..
	Expt. No. 19.—100° C. for 2 hours	
8	Nil	..
98	2 L. dead	..
109	3 L. dead	..
128	2 L. dead	..
188	Nil	..
SUMMARY	All larvæ dead	..
	Expt. No. 20.—100° C. for 3 hours	
36	1 L. dead	..
85	2 L. dead	..
156	Nil	..
185	Nil	..
288	3 L. dead	..
SUMMARY	All larvæ dead	..

(*i*) *At 50°C.*—The 1-hour exposures at 50°C. did not have any appreciable effect on the larvæ which remained alive and active. After having been extracted from the cards on the 4th day after treatment, the larvæ were kept in a glass tube with a little quantity of wheat flour ; but all died on the 12th day, probably due to starvation. The 2-hour exposures made all the larvæ half-dead, and on extraction they died on the 6th day. The 3-hour exposures killed one larva, but the majority were only half-dead ; on extraction the latter died on the 6th day. The 4-hour exposures killed many larvæ, but some remained only half-dead ; on extraction the latter died on the 6th day.

(*ii*) *At 55°C.*—The 1-hour exposures at 55°C. killed a few larvæ, but the majority remained alive and active ; on extraction from the cards they died on the 9th day of treatment, even though wheat flour was supplied to them. The 2-hour exposures made all the larvæ half-dead ; on extraction they died on the 5th day. The 3-hour exposures killed a few larvæ, but the majority were only half-dead ; on extraction the latter died on the 5th day. The 4-hour exposures killed some larvæ and made the remainder half-dead ; on extraction the latter died on the 5th day.

(*iii*) *At 60°C.*—The 1-hour exposures at 60°C. killed some larvæ and made the remainder half-dead ; the half-dead larvæ were later killed accidently, so that no observations on their post-treatment viability could be made. The 2- and 3-hour exposures killed all the larvæ.

(*iv*) *At 70°C.*—The 1- , 2- and 3-hour exposures killed all the larvæ.

(*v*) *At 80°C.*—The 1-hour exposures killed all the larvæ, but one was only half-dead. We suppose that this exceptional larva escaped death accidently, and that normally all larvæ are killed by a 1-hour exposure at 80°C. The 2- and 3-hour exposures killed all the larvæ.

(*vi*) *At 100°C.*—In the lot of 5 cards which were given a 1-hour treatment at 100°C., no larvæ were found. The 2- and 3-hour exposures killed all the larvæ.

From these experiments it would appear that at 50° and 55°C. exposures even up to 4 hours do not kill the larvæ. Exposure at 60°C. for 2 hours and above kill the larvæ, while from 70°C. upward even 1-hour exposures kill them. To be certain of results, exposures should be prolonged by one or two hours beyond the time suggested by the above results. As thicker materials will take longer to get heated to the required temperature, some allowance should be made for this factor.

(*b*) *Viability of larvæ after heat treatment* (Table 3)

It is interesting to observe (Table 3) that while exposures to temperatures of 50°C. and 55°C. do not kill the larvæ outright, they nevertheless have a marked adverse effect on their subsequent viability, the degree of effect showing apparent correlation with the increase of temperature as well as with the duration of exposure. The 1-hour exposures at 50°C. did not have any apparent effect on the larvæ which remained fully alive and active ; on extraction from the cards on the 4th day after treatment, the larvæ remained alive up to the 12th post-treatment day when they died, presumably due to starvation. However, the increase of duration of exposure at 50°C. beyond one hour visibly shortened the post-treatment viability of the larvæ which in the 2- , 3- and 4-hour experiments died on the 6th post-treatment day. The 1-hour treatments at 55°C. not only killed a few larvæ, but the post-treatment viability of all the remainder (all alive and active) was also shortened to 9 days in contrast to 12 days at 50°C. The results of the 2- , 3- and 4-hour exposures at 55°C. similarly show a reduced post-treatment viability from 6 days at 50°C. to 5 days at the alternative temperature. At the remaining temperatures few or no larvæ survived the treatments.

TABLE 3.—Summary of results of exposure to heat treatments of cards infected with *Gastrallus indicus*, to show the immediate effect of treatment on the larvae, and on their post-treatment viability. *From* (Table 2).

Duration of treatment	(A)—Immediate effect of treatment on larvæ (3–4 days after treatment), to various temperatures of exposures						(B)—Post-treatment viability of larvæ after extraction from cards 3–4 days after treatment at various temperatures of exposure. Day of death (after treatment) of surviving larvæ					
	50°C.	55°C.	60°C.	70°C.	80°C.	100°C.	50°C.	55°C.	60°C.	70°C.	80°C.	100°C.
1 hour ..	All alive and active	Majority alive and active; a few dead	Some half-dead; others dead	All dead	All dead; one half-dead (accidental survival?)	(No larva)	12th day	9th day	?	..	?	..
2 hours..	All half-dead	All half-dead	All dead	All dead	All dead	All dead	6th day	5th day	..	..	..	..
3 hours..	Majority half-dead; one dead	Majority half-dead; a few dead	All dead	All dead	All dead	All dead	6th day	5th day	..	..	..	..
4 hours..	Many dead; some half-dead	Some half-dead; others dead	X	X	X	X	6th day	5th day	X	X	X	X

IV.—RECOMMENDATIONS

Primarily as a result of the experiments discussed above, the following recommendations regarding the control of infection of the larvæ of the bookworm, *Gastrallus indicus*, are made :—

(*a*) *Remedial measures*

1. Thoroughly examine everything in the nature of paper, books, cardboards, etc., in the infected premises such as rooms, almirahs and racks, and sort out *all* the infected material, however, slightly infected. Every infected item should be marked in a special manner (*e.g.*, a remark in red pencil) so that after the current infection has been killed by treatment, it may not be confused with subsequent new infections. The remainder of the material and the premises should be thoroughly cleaned.

2. The infected material should, in small lots, be air-heated in suitable ovens at 60°C. for 4 hours or at 70°C. for 3 hours. Higher temperatures are not recommended as they would adversely effect the durability of paper, palm-leaves, etc. But should such an adverse effect be of no consequence (as in the case of the library cards experimented with here), exposures to higher temperatures may be made. Thicker materials would take longer to acquire the requisite temperatures than thinner ones.

In the summer months in the Indian plains, where high temperatures prevail, exposure to the sun could reasonably be recommended, provided that the minimum requisite temperatures are attained for the required duration.

(*b*) *Preventive measures*

3. The infection of *Gastrallus indicus* always arises by lack of regular cleaning and is built up by long neglect. Consequently, the following precautions should be taken :—(*a*) Thorough cleaning of the premises (rooms, almirahs, shelves, etc.) and the material susceptible to infection (*e.g.*, books, papers, etc.) should be done periodically and regularly, at least once a year. As the insects again become active in spring after comparative inactivity in winter (except in artificially heated rooms), the annual cleaning is best done in early spring (February). (*b*) Books, etc., should normally be kept in closed almirahs which are liberally charged with sufficient quantities of naphthalene (enough to give a permanent smell), the naphthalene (which volatilizes rapidly) being replaced every few months. This precaution, frequently neglected, will keep away not merely *Gastrallus indicus* and other bookworm beetles but also other insects which harm books, etc., *viz.*, the silverfish (Lepismidæ) and cockroaches (Blattidæ).

V.—SUMMARY

1. The known records, some new, of the damage done by the Indian bookworm beetle, *Gastrallus indicus* Reitter (Insecta : Coleoptera : Anobiidæ), to books, palm-leaf records, etc., in India and Burma are summarised.

2. On material obtained from a recent infection of library cards in Dehra Dun, experiments were carried out to determine the minimum effective temperatures and duration required for the hot-air treatment to kill the existing infection of larvæ. The following temperatures were experimented with, the duration of exposure being 1–4 hours :—50, 55, 60, 70, 80 and 100°C.

3. (*a*) It was found that the minimum effective temperatures to kill all the larvæ were 60°C. for 2 hours and 70°C. for 1 hour, but for safety the minimum exposures recommended are 4 hours at 60°C. and 3 hours at 70°C. Above 70°C., even a 1-hour exposure kills the larvæ,

but these higher temperatures are not recommended since they are liable to have a deleterious effect on paper and other materials exposed. (*b*) Among other general recommendations are the periodical cleaning of the premises, almirahs, etc., and the charging of the latter with naphthalene to ward off insect attack.

4. Observations on the viability of the larvæ after the heat treatments show that at 50° and 55°C. the post-treatment viability declines with the increase of temperature and of the duration of exposure. At higher temperatures, practically all the larvæ are killed even with an exposure of about 2 hours.

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EXPLANATION OF PLATE I

The bookworm beetle *Gastrallus indicus* Reitter.

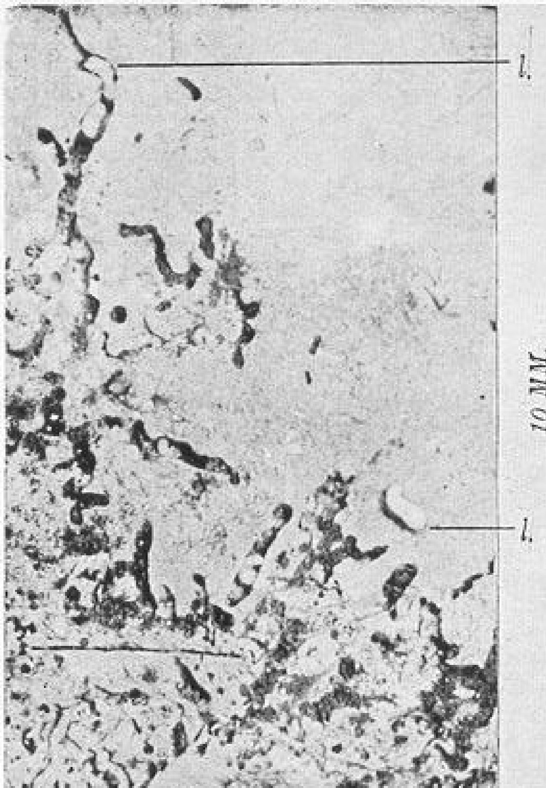
Lettering : g., larval gallery ; *h.,* emergence hole of beetle ; *l.,* larva.

FIG. 1.—Surface view of a heavily infected library card, with the galleries partly exposed to show the larvæ. × 2.

FIG. 2.—Surface view of moderately infected library card, showing the externally visible portions of galleries and the "shot holes" (emergence holes) of the beetle. × 2.

FIG. 3.—Dust taken from the galleries. × 2.

FIG. 4(*a*).—Four larvæ from young to mature ones. × 3. (*b*) Four beetles as seen from above. × 3. Note variation in size.



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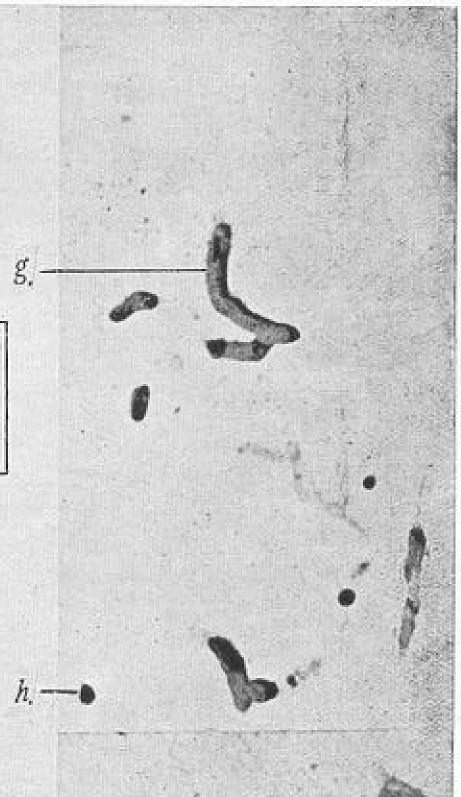

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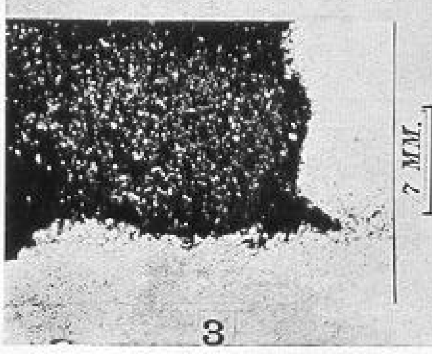

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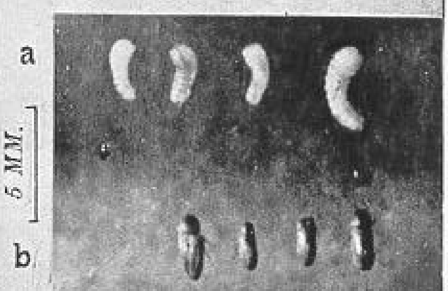


4

ISOLATION OF COSTUS OIL FROM COSTUS ROOTS

BY B. S. VARMA
Forest Research Institute, Dehra Dun

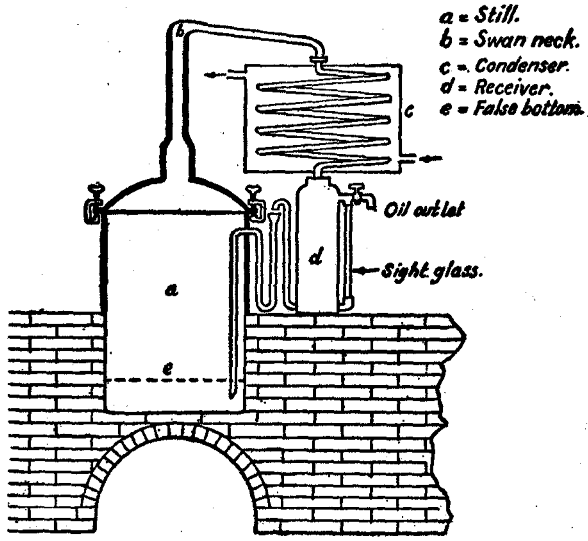
Costus oil is highly prized in perfumery, being largely used for blending and as fixative. It is obtained from the roots of *Saussurea lappa* C. B. Clarke. The plant which is herbaceous growing up to 7′ in height belongs to the Compositæ family. In Kashmir it is found wild in the snowy regions of Western Himalayas at 8000–12000 feet. It is also cultivated to some extent at the same as well as higher altitudes in Lahoul, Garhwal, Nepal and other neighbouring regions. Formerly the roots of this plant used to be exported in considerable quantities to China where they were burnt as incense in temples. Large quantities were also exported to Germany for the distillation of the oil.

The oil is obtainable from the roots by the usual method of water distillation, and the yield is reported to be one per cent by Schimmel & Co.[1], and to be varying from 0·6 to 2·8 per cent by Naves[2]. However, investigations carried out at the Forest Research Institute, Dehra Dun, over a number of years, have shown that by extracting the roots with alcohol and subsequently subjecting the extract to steam distillation much higher yields varying from 1·5 to 5·0 per cent could be obtained, depending upon (1) locality (2) age of the plant and (3) time of collection[3].

With a view to evolving a suitable method for the isolation of the oil to the maximum extent, several experiments have been carried out. It has been found that the main reason for the low recovery of the oil recorded in the water distillation method is due to the emulsification of the oil with the distillate-water and consequent partial non-separation of the former from the latter, which phenomenon in turn, is due to the oil having a density very close to that of water. To obviate this difficulty a still, improvised with an arrangement for automatic return of the distillation water into the still, has been tried. In a sample known to contain 2·2% of the distillable oil, the yield by this method with a distillation period of 30 hours has been found to be as much as 1·9 per cent, while the yield by the ordinary method of water distillation is only 0·8 per cent. The equipment as improvised for this method of automatic cohobation is diagrammatically represented below :—

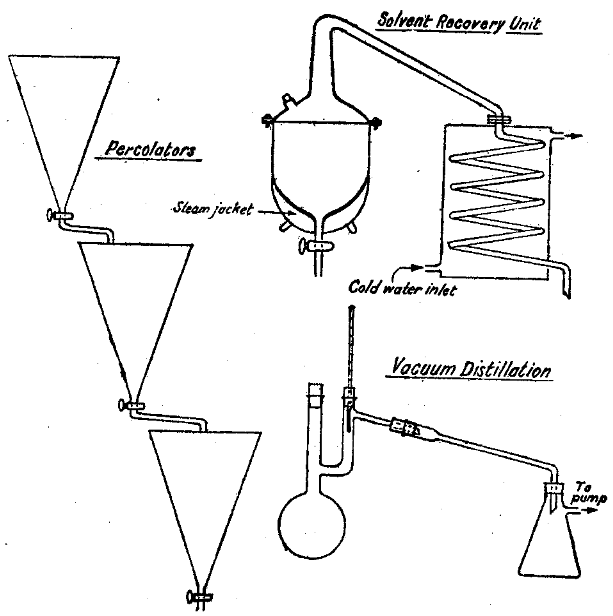
DIAGRAM I.

Automatic Cohobation Still.



With a view to further improving the yield of the oil, as an alternative to simple or cyclic water distillation, a method of solvent extraction has been evolved. By extracting the roots with alcohol and distilling off the solvent, a thick resinous mass results. After removing the resins by treatment of the extract with 2% NaOH and its subsequent distillation under high vacuum, the oil is obtained in a yield of 4·0 to 5·0 per cent. Details of the extraction are as follows :—

DIAGRAM II.



The finely powdered costus roots (1 kilogram) are soaked over night in 95 per cent alcohol (4 litres) in a percolator, and the resulting extract is drawn off the next day. The operation is repeated twice taking only 3 litres of alcohol each time. The solvent is then recovered from the combined extracts, when a thick resinous mass is left behind. The latter is dissolved in ether (1 litre) and extracted twice in separating funnel with 250 cc. of 2% sodium hydroxide. After drawing off the alkaline solutions which have dissolved most of the resins, the ethereal solution is washed with water till it is free of alkali. It is then dried over anhydrous magnesium sulphate and distilled on a water bath for the recovery of the solvent. The residue is a dark coloured viscous oil and is obtained in a yield of 70 grams. The viscous oil is subsequently distilled under vacuum in a Claissen's flask. The operation requires much skill and experience, since there is a lot of frothing during distillation. After slowly bringing down the pressure of the distillation to 10 mm. the contents are heated very gradually. The distillation which starts at 60°C., is carried on till the contents in the flask show signs of decomposition by giving out white fumes (215°C.). The total oil thus collected comes to about 40–50 gms. (4·0–5·0 per cent yield). The yield percentage and the physical data for the different fractions when the oil is fractionally distilled under reduced pressure are as follows. The yields of the different fractions as obtained by Semmler & Feldstein are also included for comparison.

TABLE I

Boiling range		Yield of Semmler and Feldstein %	Yield of the author %	Sp. Gr. 20°	Refractive index	Optical rotation
1. 60°–150°/11 mm.	..	14·8 (total)	3·8	0·9130	1·4820	+ 15·0°
2. 150°–160°/11 mm.	..	14·4	1·8	..	1·4845	+ 16·8°
3. 160°–175°/11 mm.	..	12·0	9·1	0·9361	1·4882	+ 16·4°
4. 175°–190°/11 mm.	..	9·2	6·9	0·9981	1·5020	+ 19·4°
5. 190°–200°/11 mm.	..	14·4	14·9	1·0448	1·5108	+ 25·6°
6. 200°–210°/11 mm.	..	14·4	28·0	1·0725	1·5150	+ 30°
7. 210°–215°/11 mm.	..	} 13·0	16·6	1·0805	1·5200	+ 27·2°
Residue	..		19·0	..	..	..

It may be noticed that during the course of distillation the fraction coming over between 180°–200°/11 mm. begins to congeal in the condensing tube. It is made to flow down into the receiver by slight warming. On cooling this fraction deposits a colourless crystalline solid which can be filtered under suction. The data given in the above table are for the oily portion resulting after the removal of the crystalline solid which has been shown to be a new lactone and is named Saussurea-lactone. The nature and the properties of this lactone are described elsewhere[4].

The solvent-extracted oil, as should be expected, is found to be slightly differing from the samples obtained by the other methods. The characteristics of the samples of the oil as recovered by the three different processes are given below :—

TABLE II

		Oil obtained by water distillation I	Oil obtained by automatic cohobation still II	Oil obtained by solvent-extraction (after filtering off the solids) III
Yield ..	..	0·8%	1·9%	4–5%
Consistency ..	..	thick oil	viscous oil	viscous oil
Colour ..	..	yellow	brownish yellow	brownish yellow
Boiling range ..	..	60°–210°/11 mm.	60°–215°/11 mm.	60°–215°/11mm.
Density at 30°C. ..	..	0·939	1·0360	1·0460
Refractive index at 30°C.	..	1·4932	1·5120	1·5135
Optical rotation at 30°C.	..	+ 15·12°	+ 19·32°	+ 23·8°
Acid value ..	..	7·8	15·3	6·7
Ester value ..	..	42·9	110	180
Ester value after acetylation	..	74·7	175	214

Though differing in some of the constants from the other samples, the solvent-extracted oil is very similar in odour and aroma to them. Samples I and III were sent for evaluation and opinion to an expert in perfumery and his report is as follows. "After about 160 hours exposure, the two specimens were resembling each other as regards their olfactive perceptions. The steam-distilled specimen (I) ceased giving any odour after 32 days while the other sample (III) (the solvent extracted) exhibited slight odour even then". An Australian firm has reported that "the sample (III) was found to be of excellent quality". The editor of the Soap, Perfumery and Cosmetics, London has expressed the opinion that this oil is of very good quality and an excellent perfume material.

In India the blending of perfumes has not developed to any large extent and, therefore, the internal consumption of this oil is insignificant at present. With the country becoming more and more perfume-minded, the art of blending is sure to develop with consequent demand for fixatives like the costus oil. In countries like U.K., France and America, this oil has a high reputation in the field of perfumery and is sold at fabulous prices. For example, in London its price is reported to be between 550/- and 600/- shillings per pound, in Grasse (France) it varies from 55,000 to 70,000 francs per kilogram, and in New York, it is quoted at 25 dollars an ounce. Before the outbreak of the last war, Kashmir had been exporting 2,000 to 4,000 maunds of costus roots annually. Garhwal forests in Uttar Pradesh and Kulu forests in the Punjab (India) were also producing another 1,000 maunds each. Thus with plenty of raw material in the country and the high price of its essential oil, there is a vast field for the manufacture of the oil in this country.

My thanks are due to Dr. S. Krishna, late Biochemist and Vice-President, Forest Research Institute and Colleges, for the guidance given in this work.

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SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART V(*c*) (Stress Diagm. Method)

(*Continued from the* "Indian Forester", *June 1951, page 414*)

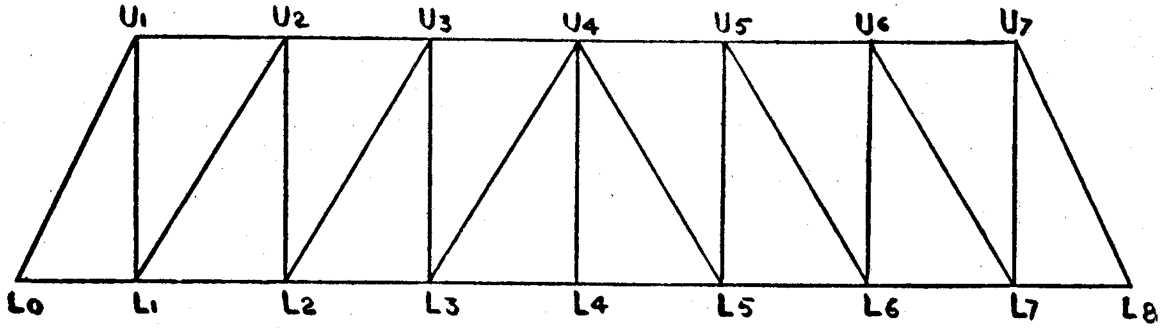


fig. 130.

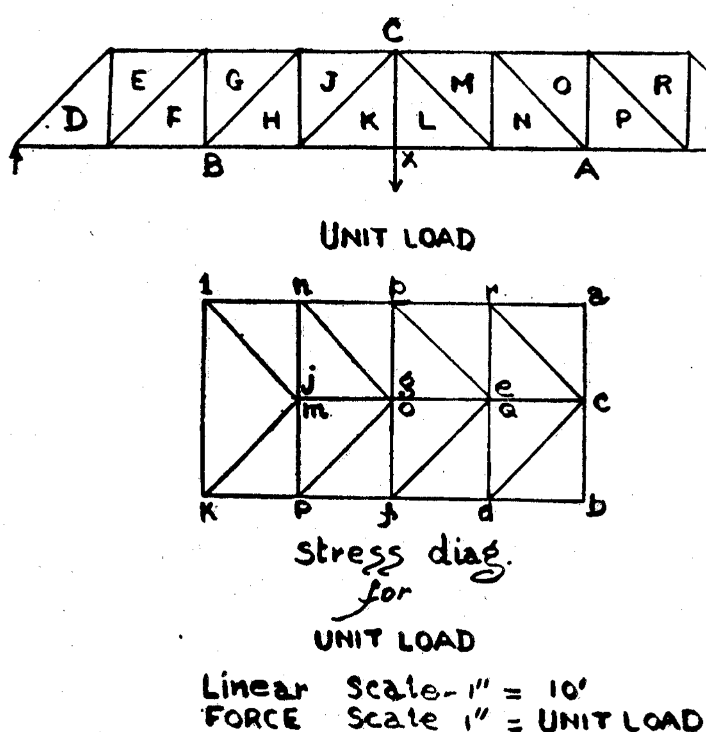


fig. 131.

(L) Now find stresses (i.e., forces) in different members of Howe truss due to a 'unit load' placed at point X in Fig. 131, frame diag., as per method shown in para (E) page 403, *Indian Forester*, June 1951. The result of the stress diag. of Fig. 131 gives the following table :—

TABLE V

Member of Howe truss named as per Fig. 131 frame diagm.	Equivalent corresponding member of Howe truss named as per Fig. 130	Magnitude of stress due to a 'Unit Load' placed at point X (i.e., middle of span) 'U'	Member of Howe truss named as per Fig. 131 frame diagm.	Equivalent corresponding member of Howe truss named as per Fig. 130	Magnitude of stress due to a 'Unit Load' placed at point X (i.e., middle of span) 'U'
1	2	3	1	2	3
Bottom Boom :		Tons	Diagonals :		Tons
$L_0 L_1 = L_7 L_8$ ..	DB = RA	0·5	$L_0 U_1 = L_8 U_7$ ..	CD = CR	0·7
$L_1 L_2 = L_6 L_7$ ..	FB = PA	1·0	$L_1 U_2 = L_7 U_6$ ..	EF = QP	0·7
$L_2 L_3 = L_5 L_6$ ..	HB = NA	1·5	$L_2 U_3 = L_6 U_5$ ..	GH = ON	0·7
$L_3 L_4 = L_4 L_5$ ..	KB = LA	2·0	$L_3 U_4 = L_5 U_4$ ..	JK = ML	0·7
Top Boom :			Verticals :		
$U_1 U_2 = U_6 U_7$ ..	CE = CQ	0·5	$L_1 U_1 = L_7 U_7$ ..	DE = RQ	0·5
$U_2 U_3 = U_5 U_6$ ..	CG = CO	1·0	$L_2 U_2 = L_6 U_6$ ..	FG = PO	0·5
$U_3 U_4 = U_4 U_5$ ..	CJ = CM	1·5	$L_3 U_3 = L_5 U_5$ ..	HJ = NM	0·5
			$L_4 U_4$ ..	KL	1·0

Note.—The results of the above table will be useful in arriving at the deflection of the Howe truss due to Dead and Live loads coming on the bridge as will be seen in para (M)(5), page 520 below.

(M) Calculations for Deflection of the Howe truss :—

Procedure :

(1) We consider the following loads on each truss.

(*a*) Dead load over each truss = Three times the actual dead load over each truss (refer Part I).
= 3 × 10,000........ [refer Part V(*a*), Appendix I]
= 30,000 lb. = 13 Tons (approx.).

(*b*) Live load over each truss = 20 Tons [refer Part V(*b*), para (B)(5)].

(2) From para (M)(1)(*a*) and (*b*) above we find that in calculation of deflection, the ratio of live load to dead load, i.e.,

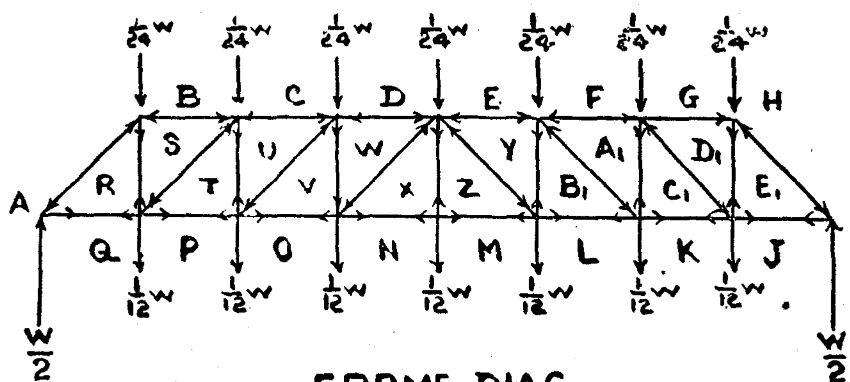
$$\frac{\text{Live load}}{\text{Dead load}} = \frac{20}{13} = 1\cdot54 \text{ (approx.)}.$$

(3) Now find the stresses (i.e., forces) in members of Howe truss due to

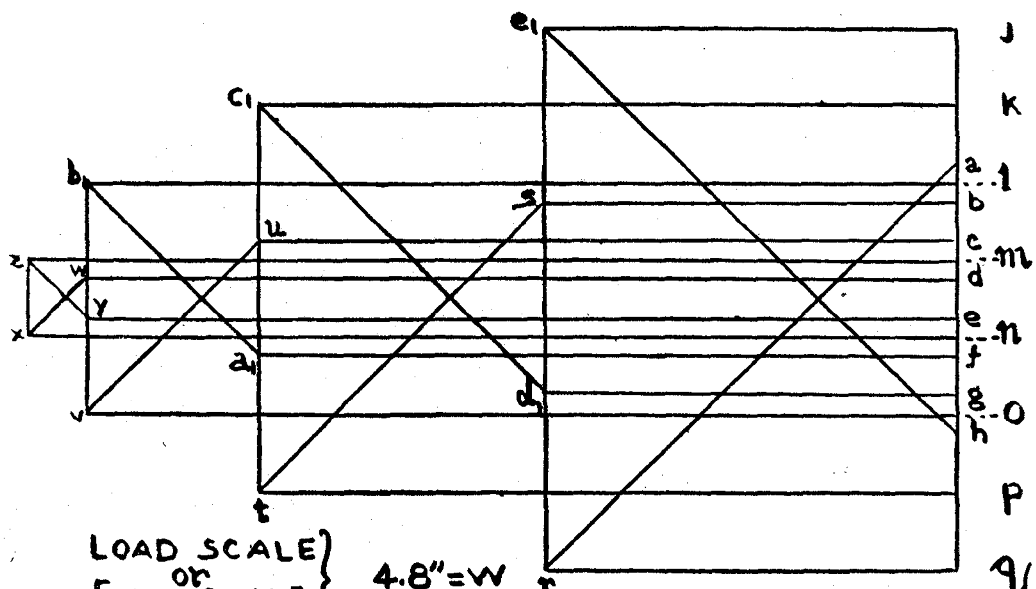
(*a*) Dead load over each truss of 13 tons and

(*b*) Live load over each truss of 20 tons

from stress diagm. of Fig. 129(*b*), by substituting the value of
W for dead load = 13 tons and value of
W for live load = 1·54 times 13 tons and
measuring out forces in different members of Howe truss due to para (M)(3)(*a*) and (*b*) above and annumerating the results as in Table VI below we have



FRAME DIAG
LINEAR SCALE 1" = 10"



LOAD SCALE or FORCE SCALE } 4.8" = W

W = Actual dead load of material of Bridge comming over one truss including dead wt. of truss.
= 4.5 Tons.

Or W = Twice 4.5 Tons = 9 Tons for B.M. calculations.

Or W = Thrice 4.5 Tons = 13 Tons for Deflection calculations.

fig. 129.(b)

TABLE VI

Member of Howe truss named from	Magnitude of Dead load stress for Deflection purposes	Multiplying factor to arrive at Live load stress	Magnitude of Live load stress	Magnitude of Total stress (i.e., Dead + Live)
Fig. 129(*b*)	Fig. 129(*b*)			F
Bottom boom :	Tons	Times	Tons	Tons
RQ = E_1J ..	5·68	1·54	8·80	14·48
TP = C_1K ..	9·75	„	14·85	24·60
VO = B_1L ..	12·19	„	18·56	30·75
XN = ZM ..	13·00	„	19·80	32·80
Top boom :				
BS = GD_1 ..	5·68	„	8·80	14·48
CU = FA_1 ..	9·75	„	14·85	24·60
DW = EY ..	12·19	„	18·56	30·75
Diagonals :				
AR = HE_1 ..	8·12	„	12·39	20·51
ST = D_1C_1 ..	5·77	„	8·80	14·57
UV = A_1B_1 ..	3·40	„	5·14	8·54
WX = YZ ..	2·30	„	3·02	5·32
Verticals :				
RS = E_1D_1 ..	5·14	„	8·25	13·39
TU = C_1A_1 ..	3·52	„	5·41	8·93
VW = B_1Y ..	2·00	„	2·95	4·95
XZ ..	1·08	„	1·67	2·75

(4) Now find extension (say X_1, X_2, X_3, ...) in each bar due to the loadings (Dead + Live) in para (3) above, by taking the sizes of the members [as arrived at from para (K)(*b*), page 412, *Indian Forester*, June 1951] and such as to sustain the total stresses 'F' (i.e., forces) developed as per Table VI, above.

(5) Multiply each extension by the stress [found from para (L), Table V and Fig. 131 above], say U_1, U_2, U_3...... developed in various members of the truss due to a 'unit load' placed at the point 'X' where deflection is required to be found out (e.g., say U_1X_1, U_2X_2, U_3X_3 ......).

(6) Add the results of para (M)(5) for all the members of the Howe truss [e.g., say (UX)].

(7) The result of para (M)(6) give the total deflection at the point where 'Unit load' was placed (e.g., δ = UX)....See Appendix VIII, para (5), page 532, Part V(*c*).

(8) If this deflection in para (M)(7) above, is within the permissible limit [usually for Bridges this limit is $\frac{1}{240}$th of the span of Bridge—here in our case of 40 feet span the permissible limit of deflection $= \frac{1}{240} \times \frac{(40 \times 12)}{1} = 2''$],

then the sizes of different members arrived at from stress diag. of Fig. 129(*b*) and Table III, page 411, *Indian Forester*, June 1951 due to dead and live load on the bridge are safe for the Howe truss against

(1) Deflection also.

[*Note.*—The sizes (sectional area) of the members of the Howe truss were calculated for safe resistance against (*a*) Bending and (*b*) Shear

(i) from the stress diag. in Fig. 129(*b*) in Part V(*c*).

(ii) also from graphical method in Part V(*a*), paras (N), (P), (Q), (R), pages 48 to 52 of *Indian Forester*, January 1951.

(iii) and from Analytical method in Part V(*b*), para (X)(4), (5), (6), pages 358 and 359, *Indian Forester*, May 1951].

and they are : chords of bottom boom 6″ × 6″. . . . refer para (N), page 48, Part V(*a*), *Indian Forester*, January 1951.

Chords of top boom	6″ × 6″	,,	,,
Diagonals	6″ × 6″	,,	,,

For verticals use one steel bar at each node point of $1\frac{1}{2}''$ diameter because the vertical RS* in Fig. 129(*b*) carries the greatest stress of all the other verticals namely 12 Tons. Tensile

$$\therefore \text{ Section area } = \frac{\text{Force}}{\text{Intensity of stress of mild steel}} = \frac{12 \times 2240}{16000}$$

$$= 1 \cdot 68 \text{ sq. inch.}$$

Now sectional area of one bar of $1\frac{1}{2}''\ \phi = 1 \cdot 7$ sq. in.

$\therefore$ Actual sectional area used > permissible area i.e., 1 ·7 sq. in. > 1 ·68 sq. in.

(9) If on the other hand, the total deflection arrived at in para (M)(7) above is > the permissible deflection allowed as in para (M)(8) above,

then sizes arrived at from stress diag. of Fig. 129 and Table III on page 411, *Indian Forester*, 1951 are not safe against the actual deflection of the truss. They should, therefore, be altered to some greater sizes and actual deflection recalculated on these altered sizes of members so as to give ultimately deflection results well within the permissible deflection limit.

(N) Actual calculations of Deflection of 40 feet span Howe truss under Dead and Live loads on the bridge are as stated in Table VII (page 522).

(O) (1) $\therefore$ Total deflection of the Howe truss at the centre of the bridge is $\delta = \delta_1 + \delta_2 = 0 \cdot 98 + 0 \cdot 08 = 1 \cdot 06$ inches.

(2) We thus notice that actual deflection of Howe truss at centre (i.e., 1 ·06 inches) is less than the permissible deflection of 2″ at the centre [refer para (M)(8) page 520 above].

$\therefore$ (3) The sizes of all the members of the Howe truss are

(*a*) safe against Bending . . . . [refer Part V(*a*) and V(*b*)].

(*b*) ,, ,, Shear . . . . [refer Part V(*a*) and V(*b*)].

(*c*) ,, ,, Deflection also [refer para (O)(1) above].

* Actual calculations of sizes of verticals ought to have appeared in Pt. V(*a*) after para R on page 52, *Indian Forester*, January 1951 but was omitted by oversight.

TABLE VII

Members named from Fig. 130	No. of times the member	Length of each member	Sectional area of each member [from Part V(a)]	Total stress (i.e., force) in each member due to Dead and Live load (from table VI)	Stress (i.e., force) in each member due to 'Unit Load' (from Fig. 131 and table V)	$N\frac{(F\times U\times l)}{A}$
	N	l″	A. sq. in	'F' Tons	U	
1	2	3	4	5	6	7
Bottom boom :						
$L_0 L_1$ & $L_7 L_8$ ..	2	5 × 12	6 × 6	14·48	0·5	24·12
$L_1 L_2$ & $L_6 L_7$ ..	2	,,	,,	24·60	1·0	82·00
$L_2 L_3$ & $L_5 L_6$ ..	2	,,	,,	30·75	1·5	153·75
$L_3 L_4$ & $L_4 L_5$ ..	2	,,	,,	32·80	2·0	218·66
Top boom :						
$U_1 U_2$ & $U_6 U_7$ ..	2	5 × 12	6 × 6	14·48	0·5	24·12
$U_2 U_3$ & $U_5 U_6$ ..	2	,,	,,	24·60	1·0	82·00
$U_3 U_4$ & $U_4 U_5$ ..	2	,,	,,	30·75	1·5	153·75
Diagonals :						
$L_0 U_1$ & $L_8 L_7$ ..	2	7 × 12	6 × 6	20·51	0·7	66·96
$L_1 U_2$ & $L_7 U_6$ ..	2	,,	,,	14·57	0·7	41·59
$L_2 U_3$ & $L_6 U_5$ ..	2	,,	,,	8·54	0·7	27·89
$L_3 U_4$ & $L_5 U_4$ ..	2	,,	,,	5·32	0·7	17·38
					$\therefore \Sigma N\frac{(F\times U\times l)}{A}$	= 892·22

$$\therefore \delta_1 = \frac{1}{E} \times \Sigma N \frac{(F\times U\times l)}{A} = \frac{1}{2040 \times 1000} \times \frac{892\cdot22 \times 2240}{1}$$

$\therefore \delta_1 =$ 0·98 inches.

Note.—(1) Bottom boom, top boom and diagonals are all of Sal timber.

(2) Therefore, 'E', i.e., modulus of elasticity for sal = 2040,000 lb./sq. in.

Members named from Fig. 130	N	l″	A. sq. in	'F' Tons	U	$N\frac{(F\times U\times l)}{A}$
Verticals :						
$L_1 U_1$ & $L_7 U_7$ ..	2	5 × 12	1·76	13·39	0·5	456·47
$L_2 U_2$ & $L_6 U_6$ ..	2	,,	,,	8·93	0·5	304·43
$L_3 U_3$ & $L_5 U_5$ ..	2	,,	,,	4·95	0·5	168·75
$L_4 U_4$ ..	1	,,	,,	2·75	1·0	93·74
					$\therefore \Sigma N\frac{(F\times U\times l)}{A}$	= 1023·39

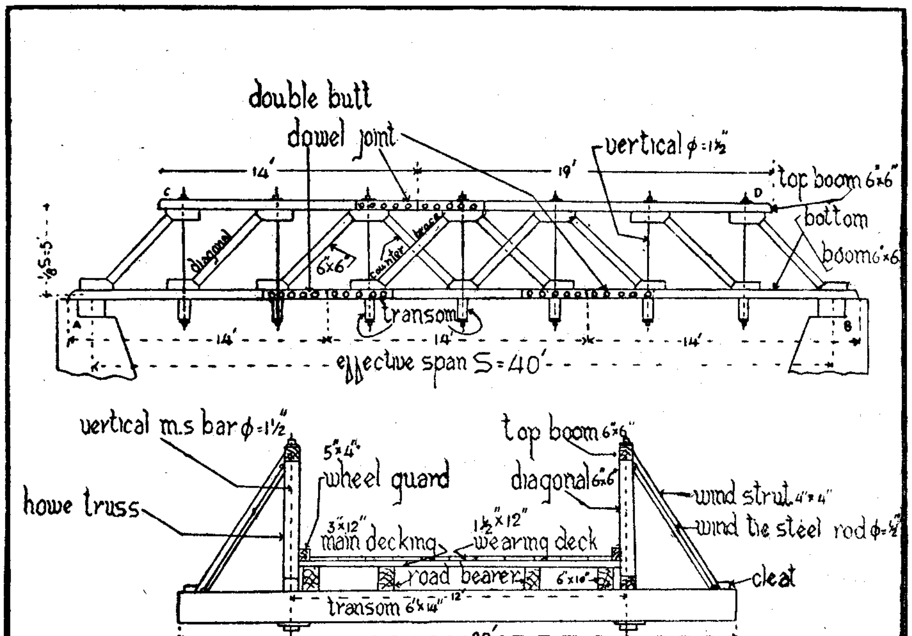
$$\therefore \delta_2 = \frac{1}{E} \times \Sigma N \frac{(F\times U\times l)}{A} = \frac{1}{30 \times 10^6} \times \frac{1023\cdot29 \times 2240}{1}$$

= 0·08 inches.

Note.—(1) Vertical members all are of mild steel rods of each 1·5″ diameter.

(2) $\therefore$ 'E' for mild steel is to be used for deflection δ_2 due to verticals of Howe truss and 'E' for steel = 30 × 10^6 lb. per sq. inch.

(P) We can now arrive at the total quantities of timber and hardware required for the bridge of 40 feet span according to above calculations as per Tables VIII and IX below :—



(Fig 132)

TABLE VIII

A complete statement in tabular form of a bridge 40 feet span, 10 feet traffic width, made of sal timber of standard structural Grade No. 2

Serial No.	Name of Items	Section b×d	Sectional area per piece	Length per piece	Cubic ft. per piece	No. of pieces required	Total cu. ft.	Constructional remarks	Previous figure reference
		in.×in.	sq. in.	ft. in.	Cu. ft.	Nos.	Cu. ft.		
1	Bridge seat ..	8×3	24	13 0	2·17	2	4·34	1*a*	40 of Pt. III.
2	Howe trusses :	..	..	..	..	..	..	2*a*, Fig. 132 to 137	
	Bottom boom ..	6×6	36	42 0	10·50	2	21·00	2*b*, Fig. 138	82 of Pt. V*a*.
	Top boom ..	6×6	36	33 0	8·25	2	16·50	2*c*	138 of Pt. V*c*.
	Diagonals including counter brace ..	6×6	36	5 9	1·44	20	28·80	2*d*	
	Verticals ..	$1\frac{1}{2}\phi$ (steel bar)	..	..	..	14	..	See Table II	
	Timber block ..	6×5	30	1 0	0·21	32	6·72	2*e*	84 of Pt. V*a*.
3	Transoms ..	6×14	84	20 0	11·66	14	163·24	3*a*	83 of Pt. V*a*.
4	Inclined struts for wind bracing truss	4×4	16	7 0	0·77	14	10·78	4*a* (5*a*)	83, 60 of Pt. V*a* and Pt. IV.
5	Inclined ties ..	$\frac{1}{2}''\ \phi$ rods	..	..	..	..	..	See Table II	
6	Roadbearers or stringers ..	5×10	50	41 0	14·24	4	56·96	6(*a*)	22, 16 and 20 of Pt. III and Pt. II.
7	Solid strutting or spacers ..	4×6	24	{ 5 0 { 2 0	0·83 0·33	3 6	2·49 1·98	7*a*	6, 8 of Pt. I.
8	Decking of Sal sleepers :								
	{ Main Deck ..	12×3	36	12 0	3·00	42	126·00	8(*a*), 8(*b*)	9 or 36 of Pt. I and Pt. III.
	{ Wearing Deck..	$12\times1\frac{1}{2}$	18	10 0	1·25	42	52·50	8(*a*), 8(*b*)	9 or 36 of Pt. I and Pt. III.
9	Guard block ..	5×3	15	0 6	0·05	20	1·00	5(*a*) of Table I, Pt. I.	6 and 10 of Pt. I.
10	Wheel guards ..	5×4	20	50 0	7·00	2	14·00	..	6, 9 and 10, Pt. I.
		Total Cu. ft. of timber required					= 506·00 approx.		

TABLE IX

Hardware required for 40 feet span bridge

Serial No.	To connect	Bolts and nuts			Iron washers			Previous figure reference	General remarks
		Dia.	Length	No. reqd.	Thick-ness	Dia.	No. reqd.		
		Inch	Inch	Nos.	Inch	Inch	Nos.		
1	To assemble Howe truss:								
	(*a*) Lengthening of top boom	$\frac{5}{8}$	22	10	$\frac{1}{4}$	1·5	20	Fig. 138	(*a*) Use 20 disc dowels of dia. $4\frac{1}{2}''$ and thickness $1\frac{1}{2}''$ each of timber *Babul*.
	(*b*) Lengthening of bottom boom ..	$\frac{5}{8}$	22	10	$\frac{1}{4}$	1·5	20	..	(*b*) Use 20 disc dowels of dia. $4\frac{1}{2}''$ and thickness $1\frac{1}{2}''$ each of timber *Babul*.
	(*c*) Vertical steel members ..	$1\frac{1}{2}$ M.S. Bar	86	14	..	..	..	132	(*c*) The vertical mild steel bar $1\frac{1}{2}''$ diameter goes through (i) Top boom, (ii) top timber block, (iii) bottom timber block, (iv) bottom boom, (v) finally through transom and nutted on both ends of the threaded vertical M.S. bar.
	with (i) Top boom ..	3 (nuts)	..	14	$\frac{1}{2}$	4	14	..	
	(ii) Bottom boom..	..	..	..	..	..	..	132	
	(iii) Transoms ..	3 (nuts)	..	14	$\frac{1}{2}$	4	14	132	
	(*d*) Timber blocks or chokes.. with (i) Top boom ..	$\frac{3}{4}$ (dowel pin)	6	14	..	..	..	84	
	(ii) Bottom boom..	,,	6	14	..	..	..	84	
	(*e*) Wooden diagonal members with Timber Blocks	,,	6	40	..	..	..	84	
2	Bridge seats with (i) abutment ..	1 (Lewis bolt)	24	6	..	..	..	40	Lewis bolt to be properly embedded in concrete.
		2 (nuts)	..	6	$\frac{1}{8}$	2·5	6	40	
	(ii) Howe truss ..	$\frac{3}{4}$ (dowel pin)	6	8	..	..	..	40	Ends of bottom booms of Howe trusses are drift bolted to bridge seat through timber cleats pinned to bridge seat with dowel pins.

(*contd.*)

TABLE IX—(*concld.*)

Serial No.	To connect	Bolts and nuts: Dia.	Bolts and nuts: Length.	Bolts and nuts: No. reqd.	Iron washers: Thick-ness	Iron washers: Dia.	Iron washers: No. reqd.	Previous figure reference	General remarks		
		Inch	Inch	Nos.	Inch	Inch	Nos.				
3	Roadbearers with (i) Bridge seat ..	$\frac{3}{4}$ (dowel pin)	6	8	..	..	..	39	Apply Fig. 39 to Fig. 132. Roadbearers are kept in position with the help of end wooden cleats and solid strutting on every alternate transom.		
	(ii) Transoms ..	”	6	12	..	..	..	38			
									Nails 3″ long and $\frac{3}{8}$″ diam.	Spikes 6″ long and $\frac{1}{4}$″ diam.	General remarks
4	Inclined struts to (i) Top boom ..	..	..	..	..	..	..	60 & 7	..	28	
	(ii) Transoms ..	..	..	..	..	..	..	..	..	28	
5	Inclined ties ..	$\frac{1}{2}$ M.S. bar	8 feet	18	..	..	..	60	..	..	
	to (i) Top boom ..	$\frac{1}{2}$ eye hook bolt	..	56	..	..	..	..	..	..	
	(ii) Transoms ..	”	..	56	..	..	..	..	..	..	
6	Main Decking to Roadbearers..	..	..	..	..	..	..	9 & 36	..	320	Two spikes for each crossing of Roadbearers.
7	Wearing Deck to Main Decking	..	..	..	..	..	..	36	400	..	Ten nails per each foot run of wearing plank along the span of bridge for one traffic lane, i.e., 10 nails per 100 sq. feet.
8	Guard block and Wheel Guard to Main Deck ..	$\frac{3}{4}$	12	20	$\frac{1}{4}$	2	40	10	..	..	

NOTE ON CONSTRUCTIONAL REMARKS FOR TABLE VIII

(1*a*) Bridge seats are fixed to masonry abutments at three places (i.e., ends and middle) by means of Lewis bolts embedded in rich cement concrete. (Refer Fig. 40, Part III).

(2*a*) Methods for launching trusses across a gap have to be improvised in the forests using available materials and standard field equipment which could be easily carried.

For short spans up to 15 feet to 20 feet :—

Gap shallow and dry :

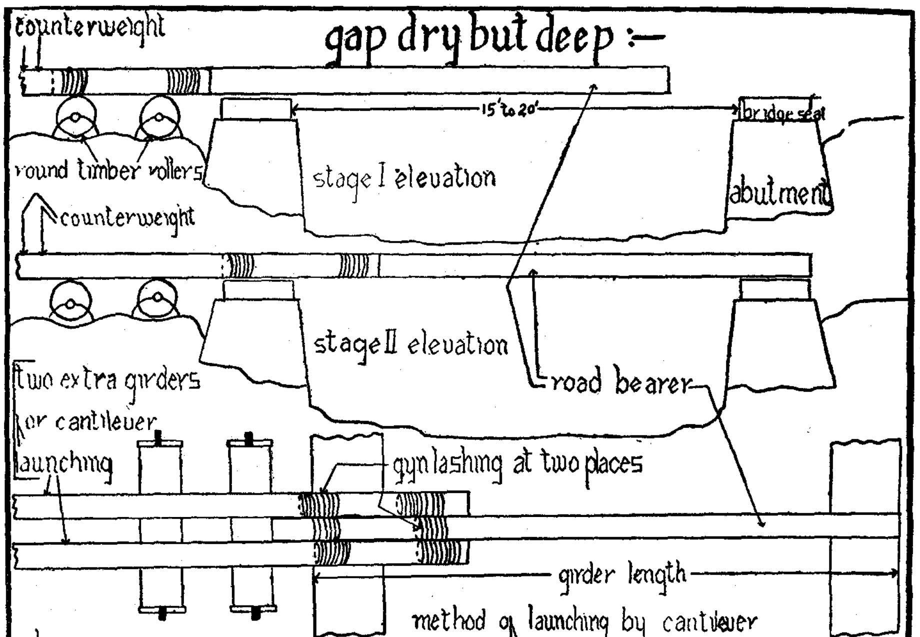
(i) Girders and roadbearers launched by moving them over rollers of round timber laid on light timber bearers or rails, etc.

(ii) Cantilever method :—(Fig. 133).

Gap dry but deep :

(*a*) Build extra length of girders or trusses as tail ends, and put counter weights on tail ends.

(*b*) Push out the girders or trusses over round timber rollers until head of girders or trusses rest on far bridge seat (Fig. 133).



(Fig 133)

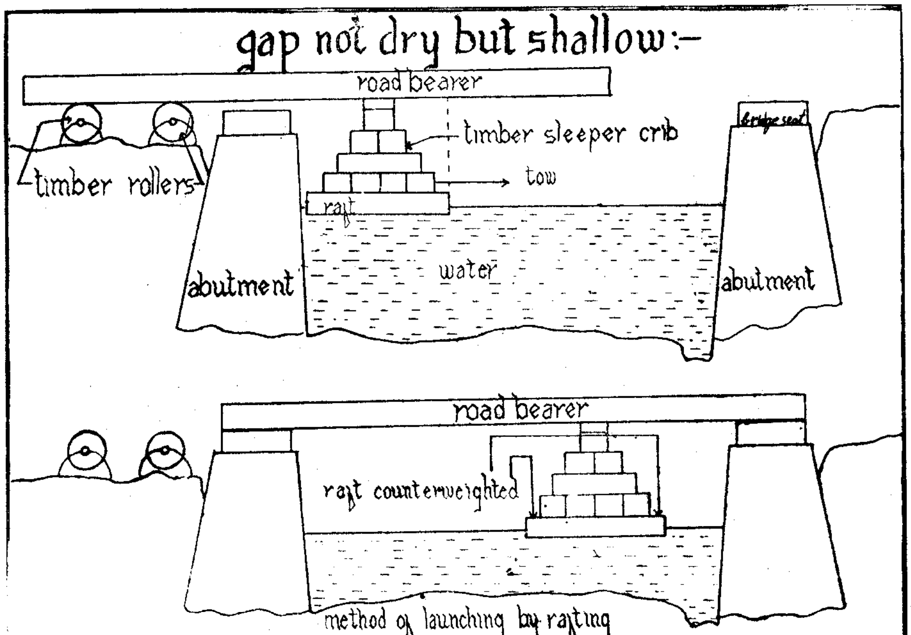
(iii) Use floating method :—(Fig. 134).

When bridge gap is not dry and the gap shallow :

(*a*) Girders or trusses pushed out over rollers of round timber until head dips on to crib work on a raft.

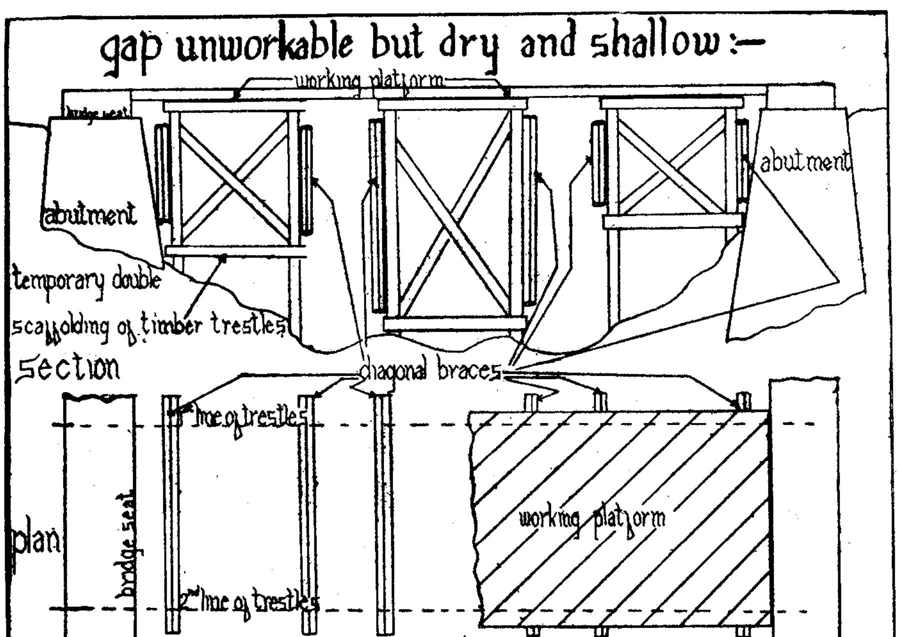
(*b*) Raft and truss (or girder) are then moved forward together until head of truss arrives over far bridge seat.

(*c*) Truss (or girder) is lowered on the bridge seat by sinking the raft slowly (by addition of false weights on the raft).



(fig 134)

(iv) By falsework :—(Fig. 135).



(fig.135)

Launching over large but shallow, unworkable dry gaps :

(*a*) Erect two temporary double scaffolding and make a working platform at a level equal to the height of the bottom booms of each truss.

(*b*) Fabricate and erect the trusses on these platforms.

(*c*) And secure them to bridge seats.

(v) Launching by help of derricks and tackles :—(Fig. 136).

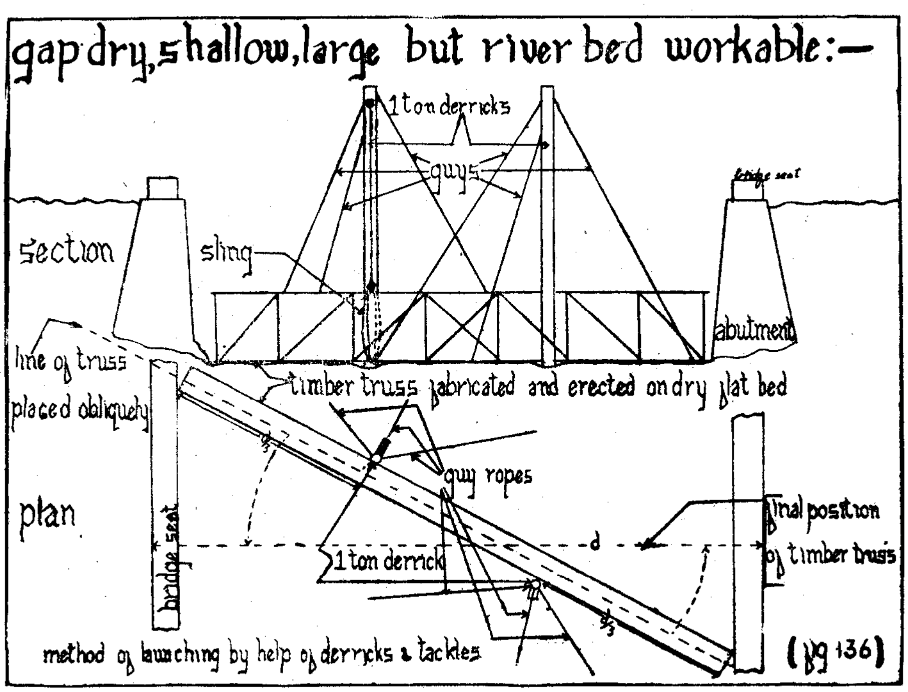
River bed dry, shallow but span of gap large (i.e., 40′ to 60′) but bed of river could be used as working platform.

(*a*) Fabricate and erect the trusses in the dry bed on flat area.

(*b*) Erect two derricks ((in our case, to take lifting load of 1 ton each). The derricks to be erected at ⅓rd and ⅔rds the distances of the gap and on opposite sides of the line of truss (Fig. 136). The position of derricks to be such as to be outside the line of the final position of trusses on the bridge seats.

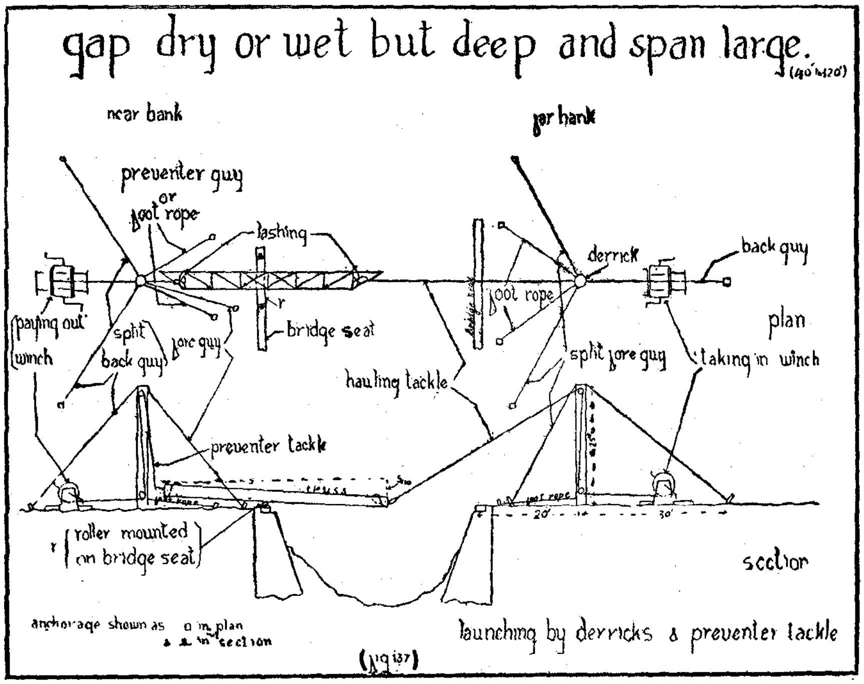
(*c*) Lift each truss separately by means of the two derricks so that the trusses are lifted from panel points of top and bottom booms at ⅓rd and ⅔rds the span distances with help of slings.

(*d*) Sit the trusses at the positions required on the bridge seats by turning them from their obliques position and secure the two trusses in vertical position by temporary bracing on top



booms so as to keep the two trusses at exact distance a part and also such that they remain vertical till the transoms are fitted.

(vi) Launching by derrick (on far bank and preventer tackle on near bank :—(Fig. 137).



River bed either dry or wet but gap not shallow and span also large, i.e., 40′ to 120′ :

(*a*) Truss or girder on rollers of round timber.

(*b*) Construct the derrick and hauling tackle on the far bank.

(*c*) Erect preventer tackle and anchorages on the near bank.

(*d*) Slid the truss on rollers (of round timber as far as it can go by cantilevering.

(*e*) Hook on the hauling tackle and haul the truss with a dip of about 1/10th the span.

(*f*) Preventer tackle in attached to the tail of the truss and to the preventer tackle anchoring.

(*g*) The truss is now launched by simultaneously 'taking-in' (i.e., pulling) on the hauling tackle and 'paying-out' (i.e., loosening) on the preventer tackle.

(2*b*) (i) Use one full length of bottom boom AB of 42 feet length (i.e., 40 feet effective span plus 2 feet bearings) and of section 6″ × 6″ if such long lengths of timber are available.

(Fig. 138) :—

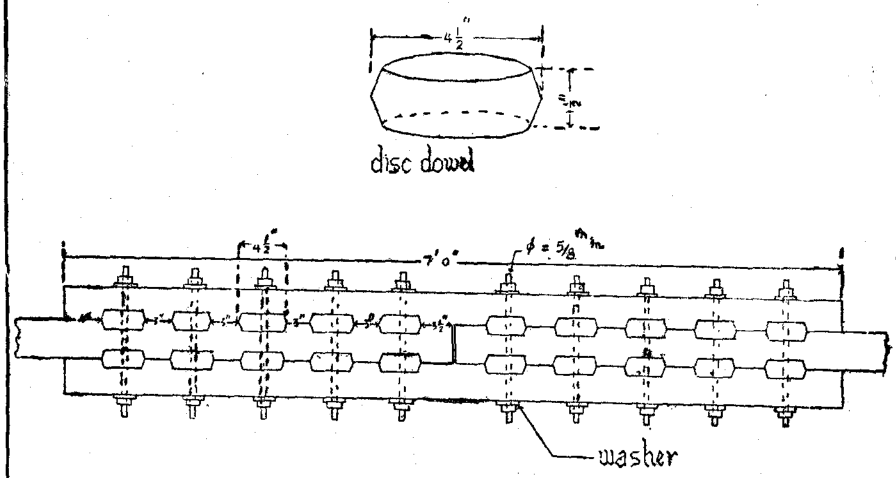


Fig 138

(ii) If long lengths are not available, break up the bottom boom in three parts and have two splicings. Each splice is made with double disc dowel butt joints consisting of 20 disc dowels* of timber Babul (*Acacia arabica*) of size $4\frac{1}{2}'' \times 1\frac{1}{2}''$ each and secured by two sal timber boards (i.e., equivalent of fish plates) of length 7 feet each and section 6″ × 6″, held by 20 Nos. bolts of $\frac{5}{8}''$ ϕ each Fig. 138.

Example.—To find out size and Nos. of disc dowels made of Babul, for splicing of bottom boom.

(1) Third panel of the bottom boom from each end is to be jointed by disc dowels.

(2) The bottom chords at these joints carry tensile stresses of 27 tons each (i.e., 60,480 lb.), (refer Table III, *Indian Forester*, June 1951 against member VO).

(3) Now by tests carried out at Forest Research Institute, Dehra Dun, it is found that one disc dowel of Babul $4\frac{1}{2}'' \times 1\frac{1}{2}''$ will carry without failure a force of 6,000 lb. (parallel to grain).

(4) As the splice has to transmit a tensile force of 60,480 lb., therefore, we require $\frac{60480}{6000} = 10$ disc dowels on each side of the splice.

(5) ∴ We require 20 dowels* for the complete joint.

* In Part V*a*, para N., page 48 and Fig. 82 by an error only eight disc dowels are shown instead of 20 dowels for the joint. For the correct sketch refer Fig. 138.

(2*c*) (i) Use one full length of top boom CD (Fig. 82) of 33 feet length and section 6″ × 6″, if such long lengths are available.

(ii) If long length of 32 feet not available, splice the top boom as in Fig. 82 with 20 disc dowels of $4\frac{1}{2}'' \times 1\frac{1}{2}''$ made out of Babul (*Acacia arabica*) as per para (2*b*)(ii) above. See Fig. 138.

(2*d*) Fix the diagonals as per Fig. 84, Part V(*a*).

(2*e*) Timber blocks or timber chocks are made use of in fixing diagonals to top and bottom booms of such sizes as to make the axis of diagonals, verticals and booms to meet in a point at every panel point. (As otherwise secondary stresses will develop at the panel points) Fig. 84, and are so designed as to have shoulders of sufficient size to take the whole horizontal component of the force in the diagonal against crushing.

(3*a*) Each transom (beginning from near bank) is fixed in its position underneath each panel point of the bottom boom.

The method of carrying out this stage of erection will depend on the method of launching of the truss as mentioned above in para (2*b*).

(4*a*) (5*a*) Inclined struts and ties for wind bracing, etc., are now put in their places and the false braces on top boom [mentioned in para (2*a*)(v)(*d*) above] then removed (refer Figs. 83, 60).

(6*a*) (7*a*) Roadbearers and spacers are now fixed on to the transoms as per Figs. 22, or 16 or 20.

(8*a*) (8*b*) Fixing of main deck and wearing deck can now be done as per Figs. 9 or 36.

The author is indebted to the following for their valued assistance in completing the series :—

Shri R. B. Mathur, A.I.F.C., Assistant Conservator of Forests, South Kheri Forest Division, U.P.

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APPENDIX VIII

[Refer Part V(*c*), para (M)(7), page 520, Part V(*c*), *Indian Forester*, August 1951]

Proof of :

$$\delta = \frac{1}{E} \Sigma \left(\frac{F \times U \times l}{A} \right)$$

where δ = total deflection at a point.

E = modulus of elasticity for the material of the member of the truss. (Here for timber sal, E = 2040 × 1000 lb./sq. in.).

F = stress (i.e., force as from stress diag. of Fig. 129) developed in each of the members of the truss under worst condition of loading. (Refer Table VI).

U = stress (i.e., force as from 'Unit stress' diag. of Fig. 131) developed in each of the members of the truss under the action of 'Unit load' placed at the point where deflection is required to be found out. (Refer Table V).

l = length of each member of the truss.

A = sectional area of each member found by design to carry the stress 'F' for that member.

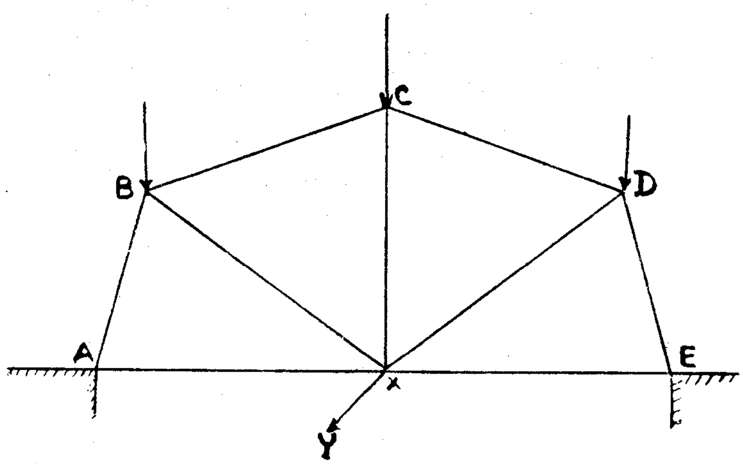


Fig. 10.
(Appendix.)

(1) Let Figure 10, represent any truss (i.e., structure) the deflection (δ) of which at a certain point 'X' in a certain direction 'Y' is required to be found out.

(2) Take any member AB and imagine for the time being that all other members are rigid (i.e., extension in these other members is not possible).

(3) If a 'Unit load' is applied at 'x' in the direction 'y' which causes a deflection of magnitude δ_1 at point 'x' then

External work done by 'unit force' = $\frac{1}{2}$ × unit force × δ_1.

Note.—(*a*) Work done = Force × distance moved in the direction of the force.

(*b*) In para (3) above, force is halved because the force is applied gradually (i.e., from zero to max.) and, therefore, average force is taken.

(4) Again,

if U_1 = stress in member AB due to 'Unit load' at 'x'

and X_1 = extension of member AB due to stress U_1

then internal work done on member AB due to internal stress $U_1 = \frac{1}{2} \times U_1 \times X_1$ ....(*b*)

Note.—The stress U_1 in member AB due to unit load at point X can be found by a 'stress diag. with a unit load in the direction of 'y' placed in the frame diag. (Fig. 10) of the unit stress diag. with the usual Bow's notation, and the stress diag. arrived at from it and then measuring off the stress in AB according to the load scale chosen.

(5) Now eq. (*a*) = eq. (*b*)

$$\therefore \frac{1}{2} \times 1 \times \delta_1 = \frac{1}{2} \times U_1 \times X_1$$

$$\therefore \delta_1 = U_1 \times X_1 \qquad \text{.............}(c)$$

i.e., deflection (here δ_1) in any direction (here 'y') of any point (here X) in a framed structure (of Fig. 10), due to an extension (here x_1) in any one member (here AB) is equal to the 'stress' (here U_1) in that member (here AB) caused by a 'unit load' placed at the given point (here X)—where deflection is required to be found out—and in the given direction (here 'y') multiplied by the extension (here x_1) in the member (here AB) due to the stress (here U_1) in the member (here AB).

(6) What is true of one member is true for all members of the structure

i.e., $\delta_2 = U_2 \times X_2$; $\delta_3 = U_3 \times X_3$ and so on.

(7) $\therefore$ Total deflection = $\delta = \Sigma (U \times X)$ ....(*d*)

Now 'x' (i.e., extension) in an ordinary loaded structure will be given by the equation.

$$\frac{\text{Stress}}{\text{Strain}} = \text{modulus of elasticity 'E'} \qquad \text{(Hooks law)}$$

$$\text{i.e., } \frac{F/A}{x/l} = E$$

$$\therefore x = \frac{F \times l}{E \times A} \qquad \text{..............}(e)$$

(8) Substituting the value of 'x' from eq. (*e*) in equation (*d*), we have

$$\delta = \Sigma (U \times x) \qquad \text{................}(d)$$

$$\therefore \delta = \Sigma \left(\frac{U \times F \times l}{E \times A} \right)$$

$$\therefore \delta = \Sigma \left(\frac{U \times F \times l}{E \times A} \right)$$

$$\therefore \delta = \frac{1}{E} \left(\frac{U \times F \times l}{A} \right)$$

Separate copies of the entire series of this article as a set of five parts can be obtained from the P.L.O., F.R.I. and Colleges, Dehra Dun, on payment.

Part I	..	.. 15 feet span Forest Timber bridge.
Part II	..	.. 20 feet span Forest Timber bridge.
Part III	..	.. 20 feet span alternate design.
Part IV	..	.. 30 feet span Forest Timber bridge.
Part V*a*	..	.. 40 feet span Forest Timber bridge Graphical method.
Part V*b*	..	.. 40 feet span Forest Timber bridge Analytical method.
Part V*c*	..	.. 40 feet span Forest Timber bridge Stress diag. method.

CORRIGENDA

Bridge span 15 feet

Part I. (August 1950 issue of *Indian Forester*)

Page	Line	For	Read
333	19	$\frac{WL}{10}$	$\frac{WL}{12}$ (for distributed load condition).
334	5	3040	3024
335	9	$\frac{1}{48}\ \frac{WL^3}{EI}$ due to concentrated	$\frac{5}{384}\ \frac{WL^3}{EI}$ due to distributed.
336	19	5494	5484
336	23	1400	700
336	24	1400	700
339	Table II	110	150
339	Table II	Hardwear	Hardware

CORRIGENDA

Bridge span 20 feet

Part II. (September 1950 of *Indian Forester*)

Page	Line	For	Read
386	11	7416	7449
386	11	7449	7500
394	Fig. 19	Masonry	Masonry

CORRIGENDA

Bridge span 20 feet (alternate design)

Part III. (October 1950 of *Indian Forester*)

Page	Line	For	Read
431	18	6972	6974
431	22	6972	6974
436	7	1440	1350

CORRIGENDA

Bridge span 30 feet

Part IV. (November 1950 of *Indian Forester*)

Page	Line	For	Read
473	3	1264	1464
476	5 to 9	Lame's	Lami's
481	4	20	30

CORRIGENDA

Bridge span 40 feet

Part V(*a*) (Graphical method) (January 1951 of *Indian Forester*)

Page	Line	For	Read
28	27	62	42
32	11	1193	1267
32	11	3545	3619
36	8	or	of
36	25	vide	wide
37	29	Home	Howe
40	10	14,400	10,000
40	10	28,800	20,000
40	27	N' d	N'd
40	36	CM	gM
45	24	a counter-bracing	Counter-bracing
46	16	to stress	the stress
48	20	8	20
48	8 (Table)	Topo boom	Top boom
48	24 add	..	Refer Fig. 138, Part Vc.
48	21	arobica	arabica
48	23	see Fig. 82	Refer corrected Fig. 132 and Fig. 138 in Part Vc.
51	11	*fe*	*fc*
52	Appendix I Serial No. 2	5/2	$5\sqrt{2}$
53	Appendix II line 6	page 36	page 37

CORRIGENDA

Bridge span 40 feet

Part V(*b*) (Analytical method) (February, March and May 1951 of *Indian Forester*)

Page	Line	For	Read
134	4	Member $L_4 L_5$	Member $L_4 L_5 = 21 \cdot 10$, i.e., same as that for stress in member $L_3 L_4$.
134	5	stress =	stress in $L_5 L_6$ =
134	7	Member $L_5 L_6$	Member $L_6 L_7$
134	10	Member $L_6 L_7$	Member $L_7 L_8$
134	12	$+9 \cdot 20$	$+9 \cdot 25$
142	Appendix III line 6	E.D D.L.	E.U.D.D.L.
147	6	Hence in eq.....	Hence in eq. (1)
147	8	rewriting eq.....	rewriting eq. (1)

(*concluded*)

A NOTE ON THE IPECAC PLANTATION IN NORTH BENGAL

BY K. C. ROY CHOUDHURY

Deputy Conservator of Forests, Forest Adviser, Sikkim State

SUMMARY

The plant Ipecac is the source of a very important drug—emetine. The original home of the plant is Brazil but it has been successfully raised in Bengal and Burma. It is a typical tropical plant thriving in areas of high rainfall. There seems to be fairly bright future for the drug.

General.—The plant Ipecac of trade is *Psychotria ipecacuanha* which produces the well known drug emetine. The plant belongs to the natural order Rubiaceæ, and is indigenous to tropical Brazil. Because of the valuable drug it produces it has been raised in other parts of the world. It was tried successfully by the Cinchona Department in Burma. In West Bengal the Cinchona Directorate has been raising the plants for some years as an experimental measure and are now doing it in a moderate scale in the district of Darjeeling. So far, the Forest Directorate, West Bengal, has not attempted to grow it.

The plant: Its requirements.—The plant is a small, succulent herb, with somewhat spreading tuberous roots. The alkaloid, emetine, is produced from the roots. The plant demands shade, a high percentage of moisture—both in the soil and in the atmosphere, and a fairly high temperature. The damp heat of the valleys in the foot-hill zone of the Himalayas suits it well. The place favoured by the Cinchona Directorate has an altitude of about 1,500 feet and an annual rainfall of about 200 inches. The area enjoys a mild winter and in summer the temperature goes to near about 100°F. The place is humid.

Ipecac has been raised by the Cinchona Directorate in the hills of Darjeeling district up to an elevation of 4,000 feet in the comparatively heavy rain-fall areas (120 to 150 inches of rainfall), but the hot valleys lower down are preferred. The plant is not likely to do well in regions of low rain-fall.

Nursery practice.—The crop is first raised in *shaded* nursery beds. The nursery beds are like those in typical permanent forest nurseries. As the plants pass their entire life in these shaded nursery beds, the shading arrangement has to be of a fairly lasting nature. In Bengal they use split bamboo in several layers. This lasts only one year or so. There is no particular choice regarding the soil, as three fourths of the depth of the beds comprise leaf-mould swept from the floor of neighbouring forests. The leaf mould of Chilauni (*Schima wallichii*) is particularly good but any other tropical species with rapidly decomposing leaf will be as good. Leaf-mould in a pulverised form is better. Leaf mould has been found particularly suitable for soil working, retention of moisture. In addition to supplying required fertility, they help the roots to develop the characteristic tuberous shape, on which the production of the drug depends. Aspect, likewise, is a minor matter as there is overhead shade. As has already been said, the shade has to be of a semi-permanent nature as the plants will be under them for three years before they mature and are harvested. The nursery beds are built on a slope so that there is no accumulation of water, and are raised 8 to 9 inches from the ground, by the usual method of bordering the edges with a couple of poles. Usually these are made 6 feet wide and are divided into plots 6 feet by 6 feet, to standardise and to keep proper cost of production, yield, etc., in an easy manner. Each nursery bed contains 8 to 10 such plots.

Sowing and tending.—The seeds are small and somewhat like those of *Schima wallichii* in size and appearance. These are sown closely in the nursery bed (which is duly made ready

with 5 to 6 inches of fine leaf-mould), during March–April. The seeds ripen in January when they are collected, dried and stored. Although the germination percentage is fairly high (over 80) the germination period is about 5–6 months. This is probably due to the seeds having a hard coat. It is worth while, perhaps, experimenting with pre-sowing treatment (as is done for teak seeds) to hasten the germination. The beds are watered daily.

When the seedlings are 2–3 inches high, they are pricked out to a spacing of 2″ by 2″. A second pricking out is done when the plants attain a height of 6 inches or so. The spacing after second pricking is 6″ by 6″, and this is retained till the plants are harvested. Watering is to be done every day, and more than once a day in the dry weather. The bed has to be kept moist perpetually. In this respect Ipecac is rather a fastidious plant, and as much care and labour are required as is necessary, perhaps, for a successful betel garden. The site, obviously demands a copious and perennial supply of water. Pricking and constant soil work tends to help the growth of the roots.

Harvesting.—The harvesting is done after 3 years, when the plants are dug out, the roots separated and dried in the sun. The shoot is not thrown away but given a clean cut and put in the nursery for future propagation. Thus after first harvest future production goes on from seeds as well as from cuttings. The plants start flowering from the 3rd year. Flowering starts from April–May and the seeds get ready by January next. The flowers are small and white and in heads.

Yield and value.—The average yield from a good plantation has been 2 lbs. of dried roots per plot. Occasional claims have been made for higher yield per plot, though not on a big scale. However, it is presumed that with improved technique of tending, greater yield is possible. The dried roots are saleable at Rs. 20/- to Rs. 22/- per pound, depending on their emetine content.

Future possibilities.—So long as there is demand for natural emetine, the future of Ipecac plantations is fairly bright. The production is not difficult, but constant watch is necessary. The principal factors that make up the cost are : (1) labour, which is indeed, nine tenths of total cost. (2) nursery beds along with sheds and leaf-moulds. Margin of profit can be increased by devising cheap and semi-permanent sheds, by having suitable labour saving device or by fixing sites where cheap labour is available.

Considering the intensity of care that is required to raise a successful Ipecac plantation, it is doubtful if it can be grown as a subsidiary under-crop in a forest plantation in suitable areas. The mature plant is hardly a foot in height and is likely to be swamped by weeds in the tropical wet forests that is the nearest approach to its native place. Intensive weeding and perhaps soil working will be necessary, which normally are not considered in the make up of cost of ordinary forest plantations. Any way, suitable experiment, in this direction may give us valuable information.

ECOLOGY IN PICTURES

BY C. E. HEWETSON, I.F.S.
Conservator of Forests

The purpose of this article is to discuss the production of photographs of selected groups of plants so that they will have an ecological value and to invite opinion on the extent to which the plates which follow do succeed in conveying the topic, which they were selected to illustrate. I preface this with an enquiry into the standard which should be aimed at, and some of the technical difficulties in carrying them into effect.

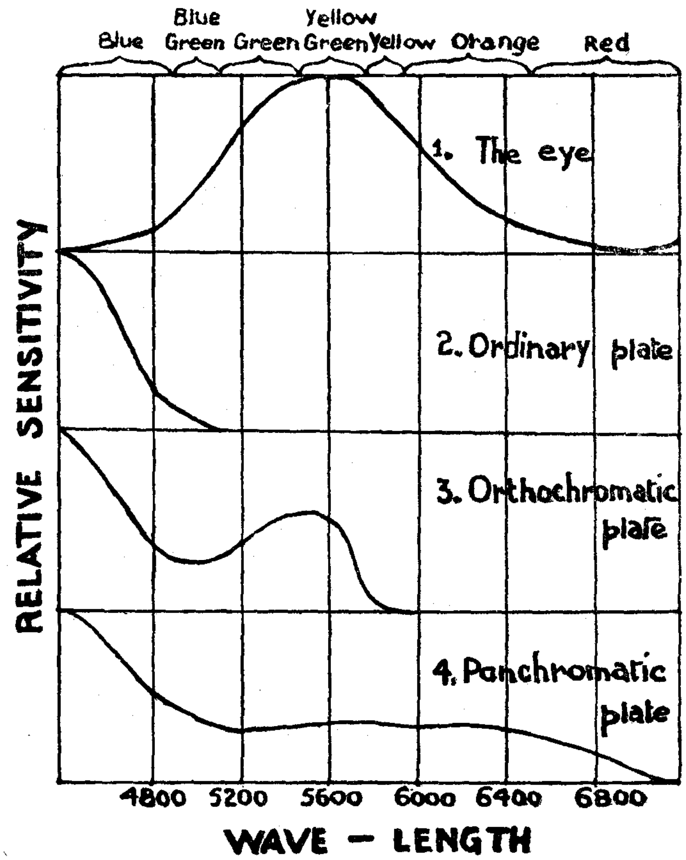
2. It is usual in any scientific article to include some illustrations of the vegetation, but too often the author has to help the reader by pointing out that the large tree in the centre is a Teak, and the ground is covered by several species of grasses. To a great extent this is unavoidable as the camera can record only a small section of the scene, which the eye scans in a second or two. Vegetation rapidly merges and trees and shrubs lose their individuality and become merely a background. The general photographer regards the trees as blocks of light and shade, and does not need to worry about their identification.

3. If we want to produce pictures in black and white of ecological value, the main plants must be recognizable and the picture must include sufficient of the entire association to demonstrate that they form part of a larger unit of vegetation. These are the minimum qualifications. To them we should add æsthetic beauty, so that the picture can be viewed with pleasure ; and that imaginative composition which will make the reader exclaim involuntarily "Now, I see what he means".

4. With these specifications what are the difficulties in the way of realization ? The first problem is to find a place where the elements, which one wishes to illustrate, are combined, and combined in a way which allow a photograph to be taken. For this a great deal of time and patience are required, and the eye of an artist to recognize where a natural picture is forthcoming and that added imaginative gift which will produce conviction ; in the way a witty epigram will convey a philosophic truth. Accepting our limitations and having chosen the spot, we have to capture the scene faithfully on the plate or film. This is a matter of scientific accuracy and experience and can be learnt by anyone. The modern photographic emulsion, the perfection of the lens, and the wide latitude given in developing and processing of the positive provide a wide margin of error. It is better, however, to produce a good negative in the first place.

5. The limiting factors in taking photos in the forest are the contrast in light and shade, the movement of the vegetation in the wind, and the necessity to use small stops in order to get depth of focus. In order to reduce the light from the sky which is richer in the wave lengths to which the emulsion is more sensitive, filters are also required. All these factors make combined demands on the speed of the emulsion. In any particular case the best combination of the variables must be chosen. For instance if a strong wind is blowing the maximum exposure will be 1/50 second, and 1/100 would be better. If the day is also dull, then f 11 may be the smallest stop ; and this will mean a reduction of the depth of focus. Under such conditions to compose the picture with some important plants close to the camera, and some far away is impossible. The picture must be varied to avoid this. On a day of brilliant sunshine, and a foreground in sharp black shade, the variation between the high lights and shadows may be greater than the film can reproduce—and the use of a filter is essential to cut down the high light from the sky. On this point I receive numerous enquiries

on the function of filters and I know of no clearer explanation than that given in the diagram taken from the Ilford Manual of Photography.



With orthochromatic material colour correction is necessary as the emulsion is much more sensitive to blue and blue-green than the human eye. A yellow filter cuts out the ultra-violet completely, and the violet strongly and the blue less strongly; with panchromatic material which is sensitive to red, it may be noticed that the plate is relatively more sensitive to the red than the human eye, and a filter is required which not only restrains the violet and blue but also cuts out some of the red. This is done by use of a green filter. As the filters absorb some of the light to which the emulsion is most sensitive, it is, therefore, necessary to increase the exposure. The number of times by which the exposure must be increased varies for different filters and the type of film or plate with which they are used. Normally the factor is between 2 and 4 times the normal exposure.

6. For the correct exposure a meter is almost essential, and anyone who intends to devote his time to this sort of photography should certainly buy a good meter. The meter tells us a lot but even then it requires to be used with intelligence. There is the inherent lightness or darkness of the subject or the reflecting power. A close up of a white dog requires less exposure than that of a black one. A landscape containing a dark foreground may require four times as much exposure as one containing only a white object—in order that the details in the shadow may be shewn. The high lights can be then dealt with in preparing the positive.

7. There are many other points which require attention and which are detailed in most elementary manuals, such as steadiness of the camera, sharp focus, etc. These need not appear here. There are, however, other refinements which can be used, and with skill they will improve the final result. In the exposure and development times there are connected variables. Over exposure and under-development will help when the light and shade are highly contrasted; conversely under-exposure and over-development will help when lighting is dull and contrast is small. There is also the use of the Hyperfocal distance. For a full discussion of this a manual of photography should be consulted. Shortly one may say that it is the distance from the camera of the nearest object which is in focus when the camera is focussed on infinity. Alternatively when focussed on an intermediate object one can calculate to what distance behind and in front of the object, the other constituents will be in sharp focus. For instance in my camera with stop f 25 and focus at 10 m., everything from 4·5 metres to infinity is in focus. This is very valuable in photographs in the forest.

8. The plates included in this article may now be examined to see what we can learn. I give the technical details as well.

Plate I (Cover Photo).—This shows Sal (*Shorea robusta*) regeneration under a spreading tree, *Zizyphus xylopyra* in the Bindra Nawagarh Zamindari in Raipur District, Madhya Pradesh. In this locality Sal is represented by individual mature trees standing in dry mixed deciduous forest, and regeneration occurs in patches only. In a recent article Shri D. D. Chopra had discussed the progress of Sal regeneration technique in Haldwani and emphasized the importance of low crowned "Kokat" in enabling Sal seedlings to become established. This plate was taken to illustrate this feature which appears to be crucial in the life history of Sal. The negative was taken on Kodak XX Pan cut film. Exposure 1/5 second at f. 18 with green filter. Rack was set at the hyperfocal distance. Exposure and development were normal. I think most officers who have worked in Sal would recognize that the seedlings are of Sal. The back of one or two leaves are turned back showing the characteristic venation. As far as the *Zizyphus* is concerned, the growth habit is very characteristic, anyhow in Central India, and I tried to include enough of the tree to show this. The back ground is in clear focus but it only conveys that the forest is dry, open deciduous. Date was March 22nd, 1951. Time 8-30 a.m.

Plates II and III.—These were taken in the Allapalli Forest in South Chanda, Madhya Pradesh. It was intended to show the "third" storey of *Curcuma sulcata* (Haines) which develops in the rains. It can be seen that at this season it is sufficiently dense to influence the shade and moisture conditions of the small seedlings of tree species. It is ephemeral, however, and the plants die down in October and by the cold season nothing remains and the ground is bare. This probably explains why it is never recorded in the lists of plants in working plans, etc. For instance in the lists of plants given in Champion's "Preliminary Survey of Forest Types in India", this plant is not mentioned. In the Bori Forests of Hoshangabad the complementary species is *Zinzibar casumunar* (*var. palamauensis*). The negative was taken on Kodak P 1200 plate : f. 18, 1/10 with green filter. The two photographs demonstrate two points in such work. Plate II is the better balanced in that the *Curcuma* is recognizable in the foreground, and some of the trees at the back are recognizable as Teak and in the small gap on the left some teak seedlings can be seen taking advantage of the extra light. Plate III captures, however, the detailed texture of the leaves of *Curcuma* and gives a better impression of the density. Date August 25th, 1949. Time 3 p.m.

Plates IV and V.—These are taken in the Kanger Reserve of the North Bastar Division, Madhya Pradesh. This is near the Southern boundary of Sal in India but it can be seen that the sal grows here as well as in any part of its range. Large trees are common but difficult to photograph. This tree was 116 feet high and 10 feet 2 inches girth. It is standing on the

PLATE II.—*Curcuma sulcata* (Haines) in teak forest—General appearance.

PLATE III.—*Curcuma sulcata* (Haines) in teak forest—Shows *Curcuma* layer in detail.

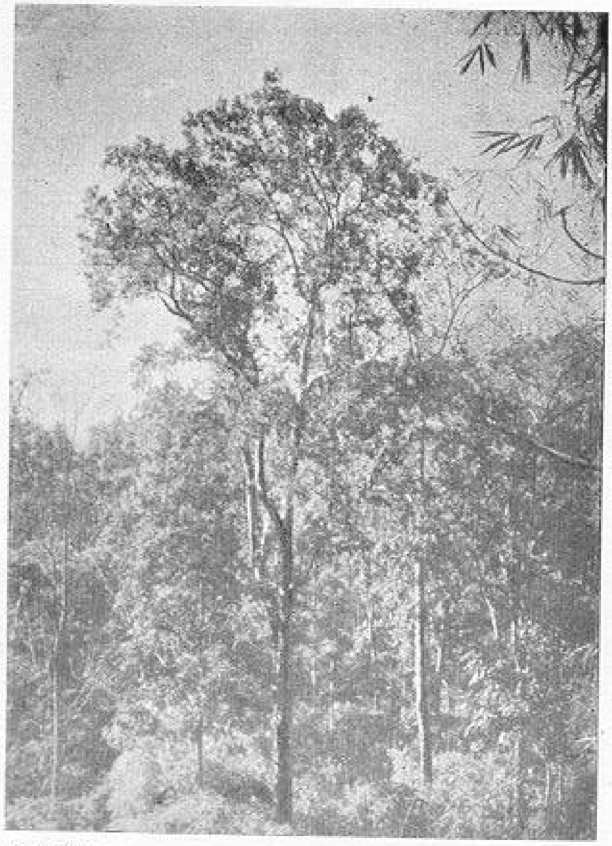


PLATE IV.—To show large tree of *Shorea robusta* (sal) in Bastar District, M.P. close to southern limit of the species.

PLATE V.—*Shorea robusta* standing in dense bamboo brake—*Oxytenanthera nigrociliata*. Bastar District, M.P.

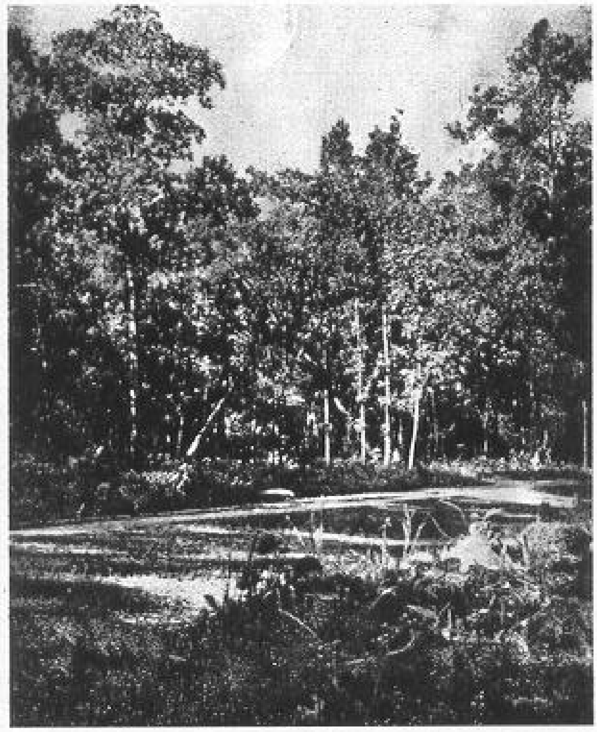


PLATE VI.—To show teak (*Tectona grandis*) and sal (*Shorea robusta*) standing together in Bensur Reserve, South Bastar.

PLATE VII.—*Wendlandia exserta* (D.C.) in flower in dry deciduous forest.

banks of the Kanger river, and at the base can be seen bamboos. These bamboos are *Oxytenanthera nigrociliata* and they form a dense thicket which is seen from the inside in Plate V. This bamboo is comparatively rare as far as one can judge from the literature. It is not mentioned in the whole of Troup's article on Sal in "The Silviculture of Indian Trees", but is recorded in "Champion's Preliminary Survey of Forest Types in India". It can be seen that it completely inhibits Sal regeneration. I have endeavoured to shew that the bamboo is not *Dendrocalamus* by bringing out the characteristic leaf sheaths on the bamboos on the left. In Plate IV the advantage of using the hyperfocal distance is seen in the reproduction of the bamboo leaves in the right upper corner.

Plate IV.—Kodak P 1200 plate f. 18—1/5. 9 a.m. on January 23rd, 1951.

Plate V.—Kodak P 1200 f. 25—1/2 Sec. Hyperfocal distance, 3 p.m. on January 23rd, 1951.

Plate VI.—This was taken in the Barsur Reserve of South Bastar Division, Madhya Pradesh which lies on the extreme S.W. limit of Sal. Further South teak is more common. In Barsur Reserve in several places teak and sal are found growing alongside each other but in my opinion not mixed. The teak is in alluvial patches or on dykes of igneous rock, or near out-crops of limestone. In this photograph, however, the teak is growing inside genuine Sal forest. The teak on the left and the Sal on the right are both good specimens. Teak 8 feet girth 103 feet high ; Sal 6 feet girth 104 feet high. The object of this photograph is to show that the two species can both flourish in the same soil. The negative is on P 1200 Kodak plate, Exposure 1/5 Sec. at f. 18. Time 3-30 p.m. on January 3rd, 1951. The sun was behind and to the left of the teak which was in deep shadow, while the top of the Sal was in bright sun light. I had hoped that the growth forms were sufficiently clearly captured to be evident even to a layman, but I find they all ask "which is the teak" ? This illustrates that lighting must be correct, but we could not reach the place earlier in the day.

Plate VII.—This shows a tree of *Wendlandia exserta* D.C. standing in dry deciduous forest. A characteristic of several species of *Rubiaceæ* with white flowers, such as *Gardenia latifolia,* is that the flowers bloom almost simultaneously and in 2–3 days at the most the flowering period is over. These species flower in the end of March and beginning of April when the forest is most open and bare of foliage. One can pick out one of these trees at a great distance as they catch the eye. This may have a biological advantage, which would be lost if the flowering were more extended : and the total effect less striking. This photograph was taken in an attempt to convey how the white flowers shine out in the bare forest. Negative on Kodak O 800 plate. Exposure 1/10 Sec. at f. 18 with yellow filter. Date March 22nd, 1951. Time 9-00 a.m.

9. Let us hope in the near future colour photography will become easily available and both the opportunities and the technical difficulties of the would be ecological photographer will be increased.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART III.—SEMI-CHEMICAL AND CHEMICAL PULPS FROM *LANNEA GRANDIS* (*JHINGAN*)

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SUMMARY

Laboratory experiments on the production of semi-chemical pulps from *Lannea grandis* (*jhingan*) suitable for wrapping papers by the neutral sulphite and soda semi-chemical processes are described. Semi-chemical pulps were also prepared by cooking a mixture of three species of hardwoods, viz., *Lannea grandis*, *Boswellia serrata* (*salai*) and *Garuga pinnata* (*kharpat*). High yields of pulps and the low consumption of chemicals are the advantages of the semi-chemical pulping process. Easy bleaching chemical pulps suitable for writing and printing papers have also been prepared from *Lannea grandis*.

INTRODUCTION

The use of old and used newspapers and magazines for packing and wrapping provisions, sweets, vegetables and fruits is not uncommon in this country. Such papers are also used in laundries for wrapping washed clothes. Not only is a large quantity of old unused newspapers imported from abroad for these purposes but also used newspapers and magazines are procured through house to house collections. Imports of old newspapers in bales and bags amounted in 1949–50 to 24,205 tons worth Rs. 78,15,938. The use of such papers is not only unhygienic but also repulsive to the civilized taste. Besides, other wrappings are also imported. There is a great demand for cheap wrapping and packing papers in this country and this demand will increase progressively with the development of trade and commerce and a rise in the standard of living of the people. The Panel on Paper, Pulp, Board and Chemical Cotton Industries set up in 1945 by the Government of India in the Department of Planning and Development estimated that the annual consumption of cheap wrapping paper excluding kraft and grease-proof papers would be 60,000 tons in 1951. At present only one paper mill in this country is manufacturing kraft paper from bamboo, and cheap packing papers are produced only on a small scale in the paper mills to meet their own requirements for packing reams of papers. There is a great scope for the manufacture of cheap wrapping and packing papers in this country.

The influential factors in the production of cheap papers are the price of the fibrous raw materials and cost of the chemicals used for pulping as well as the yields of pulps. Yields of pulps are highest (about 90–92% on the weight of the raw material) in the case of groundwood pulps but their strength properties are not good. A semi-chemical process can produce pulps of high yeild (70–80%) and of satisfactory strength properties ; the consumption of chemicals is low in this process. The basic feature of a semi-chemical process is the digestion of the raw material under relatively mild conditions which soften but do not fully pulp the

material, followed by reduction to pulp by some form of mechanical disintegration. A semi-chemical process using sodium sulphite and sodium bicarbonate for the digestion and a rod mill for the mechanical disintegration is described by Rue and co-workers[1]. According to these authors, medium grade printing papers, excellent catalogue papers, and boards with high strength, stiffness and toughness can be produced from semi-chemical pulps from hard-woods. Semi-chemical pulps from woods of the broad-leaved species can also be used as a substitute for the sulphite pulp in the production of newsprint. As pulps suitable for various kinds of papers can be prepared by a semi-chemical process in high yields with low chemical consumption, investigations have been undertaken in this laboratory for the production of papers such as cheap wrappings, writings and printings from indigenous cellulosic raw materials such as woods, bamboos, grasses and bagasse by this process. The results of investigations on the production of semi-chemical pulps from *Lannea grandis* (*jhingan*) suitable for cheap wrapping papers are described in this bulletin as an interim report. The results of investigations on the production of chemical pulps from this species are also included.

LANNEA GRANDIS—DISTRIBUTION AND USES[2]

Lannea grandis, Engler (Syn. *Odina wodier*, Roxb.) belongs to the family Anacardiaceae. It is a deciduous tree with an ashy coloured, thick, scaly outer bark exfoliating in irregular rounded plates and a mucilaginous inner bark which on blazing looks bright crimson streaked with pale pink or white. It is a moderate to large sized tree according to habitat. In the dry forests of Madhya Bharat, Madhya Pradesh, the Deccan and the Carnatic it is a moderate sized tree, generally 4 to 5 feet in girth and attaining a girth of 7 feet in favourable localities with a 10 to 15 feet long cylindrical bole. In the moister forests of the Western Ghats (Kanara, Malabar and Coorg), in the sub-Himalayan tracts of Bengal and Assam and in the Andamans and Burma, the tree attains a girth of 8 to 10 feet with about 40 feet long straight cylindrical boles. Trees with girths of about 12 feet in the Gonda forests of Oudh (U.P.) and 15 feet in Travancore have been reported. In the drier forests the percentage of the heartwood is said to be about 30% of the log volume and in the moister forests about 40–50%.

The species is distributed almost throughout the hotter parts of India, Burma, the Andamans and Ceylon. From the Beas in the North-west it extends along the lower Himalayas ascending the valleys up to about 4,000 feet. In the sub-Himalayan zone it is found in sal (*Shorea robusta*) forests as far as Assam and in the mixed deciduous forests of the plains and outer hills. From the Tarai and Bhabar tracts it extends down through Bihar, Orissa and Madhya Pradesh to the Deccan Peninsula. Kadambi[2] has described in detail the various forests in this country where this tree is found, as well as the yields of wood from this species in various States and its characteristics.

The wood is used for a great variety of purposes which include house building (chiefly planking), common furniture, packing cases, matches, water troughs, ribs and helms of boats, carving and fuel. The bark of the tree yields a useful gum. The tree is often grown as an avenue tree, but it has the disadvantage of being leafless in the hot season.

THE RAW MATERIAL

The wood used for the experiments was supplied by the Sirpur Paper Mills, Hyderabad. Debarked logs of 3·5–10 inches in diameter and 6·5–12 feet in length were received. The supply included both stem and branch wood. The logs were cut into chips about 1 inch in length. These chips were used for these investigations on the production of semi-chemical and chemical pulps.

CHEMICAL ANALYSIS AND FIBRE DIMENSIONS

The wood was chemically analysed by the Forest Products Laboratory Methods[3] except in the case of the estimation of pentosans where the TAPPI standard T 223m–48 was employed. The results of the chemical analysis are given in Table I.

TABLE I

CHEMICAL ANALYSIS OF LANNEA GRANDIS

	Property	% on the oven-dry basis except moisture
1.	Moisture	8·05
2.	Ash	1·60
3.	Cold water solubility	3·31
4.	Hot water solubility	8·53
5.	1% NaOH solubility	18·94
6.	10% KOH solubility	31·09
7.	Ether solubility	1·16
8.	Alcohol-benzene solubility	1·59
9.	Pentosans	15·40
10.	Lignin	24·11
11.	Cellulose (Cross and Bevan)	53·37

From the results it is evident that the cellulose content of this wood is sufficiently high to warrant its utilization for the production of paper. The fibre length of the chemical pulp from this wood was determined by the method described earlier[4] and was found to vary from 0·55 to 1·33 mm. with an average of 1·01 mm. From this it is clear that this wood yields short-fibred pulps. It is well known that hardwoods are generally short-fibred. For measuring the diameter of the fibres, the maximum width of each fibre was measured under the microscope. In this way the diameters of 200 fibres were measured. The fibre diameter varied from 0·0204 to 0·0324 mm. with an average of 0·0244 mm. The ratio of the average length to diameter is 41 : 1. This value is low compared to those of well-known paper making raw materials such as coniferous woods and esparto.

PRODUCTION OF SEMI-CHEMICAL PULP

The semi-chemical process described by Rue and co-workers[1] consists essentially in (1) preliminary pressure impregnation of the wood chips with the cooking liquor, (2) mild digestion of the chips with chemicals which are practically neutral and capable of maintaining neutrality in spite of the liberation of organic acids from the wood, and (3) mechanical reduction of the softened chips to pulp. The chips are first charged into a digester, preferably a globe rotary, and steamed for at least half an hour at atmospheric pressure. The digester is next filled with the cooking liquor which is forced into the chips under a pressure of about 100 lb. per square inch. The impregnation should be completed at a temperature of 120° to 125° C, since most of the organic acids are set free at 110° to 130° C, and it is advantageous to cause their liberation while the digester is full of liquor in order to prevent its corrosion by acid vapours. Sodium sulphite is an excellent reagent for the semi-chemical process because of its ready solubility, neutrality and reducing properties [5, 6]. The cooking liquor is made up of sodium sulphite mixed with sodium bicarbonate, sodium carbonate or caustic

soda. The colour of the pulp is better if sodium bicarbonate is used. At the end of the impregnation period, which may be about one hour, the liquor not absorbed by the chips is returned to the storage tank to be fortified for use in a subsequent cook. After the return of the excess impregnating liquor, the digester contents are brought quickly to a temperature between 140° and 160° C and held there for a period varying from 1 to 6 hours. Rotation of the digester or else circulation of the liquor is essential for uniform digestion. The digested chips are washed and converted into pulp by a mechanical device such as a rod mill.

A different method of digestion was followed in the investigations described here. The chips (400 gms.) were filled in the vertical stationary experimental digester and the cooking liquor consisting of sodium sulphite and sodium carbonate in the ratio of 4 : 1 was next added. In some experiments only caustic soda was used for the digestion. The digester was closed and the liquor inside was heated by means of burners applied from outside. The contents of the digester were quickly brought to the required temperature and maintained at that temperature for the required period. After this, the digester was opened, the liquor poured off and the softened chips were washed. In some experiments these softened chips were converted into pulp in an Asplund Defibrator and in other experiments a Kollergang was used for this purpose. The pulp obtained in this way was beaten in the Lampen Mill to the required degree of freeness. In some experiments the beating was carried out in the laboratory Kollergang. Pulp sheets were made on the standard sheet-making machine recommended in the Second Report of the Pulp Evaluation Committee to the Technical Section of the Paper Makers' Association of Great Britain and Ireland, and were tested for their strength properties.

In the case of the neutral sulphite semi-chemical process digestions were carried out using 6%, 15% and 18% sodium sulphite (on the basis of the air-dry raw material) and 25% of sodium carbonate (on the basis of sodium sulphite). In the case where 6% sodium sulphite was used, the softened chips were defibrated for 15 minutes in the Asplund Defibrator, while in cases where larger quantities of the sulphite were used, the defibration was carried out for 7½ minutes in the same machine. The defibrated pulps were beaten in the Lampen Mill to different degrees of freeness to study the effect of beating on the strength properties of the semi-chemical pulps. The results of the neutral sulphite semi-chemical pulping are given in Table II.

Since most of the paper mills in this country have no equipment for the preparation of sodium sulphite by passing sulphur dioxide into soda ash solution, some experiments were carried out by the semi-chemical process using 10% and 12% caustic soda (on the weight of the raw material). In one set of these experiments the softened chips were defibrated in the Asplund Defibrator for 7½ minutes and then beaten in the Lampen Mill to different degrees of freeness. In another set of experiments the softened chips were defibrated in the factory Kollergang for 15 minutes and beaten to different degrees of freeness in the laboratory Kollergang. In one experiment the softened chips were defibrated in the factory Kollergang for 15 minutes and beaten in the Lampen Mill to different degrees of freeness. The results of these soda semi-chemical pulping experiments are given in Table III.

PRODUCTION OF SEMI-CHEMICAL PULP BY COOKING OF MIXED SPECIES

One of the difficulties in the utilization of hardwoods of the tropical forests for paper-making is the occurrence of a large number of species in one and the same forest. The availability of any one species even in a reasonably big area is not sufficient to maintain an economic paper-making unit. The establishment of conditions for digesting a mixture of such species will be of great help in the economic utilization of such woods. It has been found that the difference which exists between autumn and spring fibres of the same species is a favourable factor in paper resistance[7]. Villiere[8] found that when a mixture of fibres with different

anatomical properties were subjected to a given cooking procedure, the paper-making properties of the resulting pulp fell between those of the pulps given by the different fibres making up the mixture. This author compared the pulps from the spring-wood and summer-wood of Scotch pine in relation to that of the wood as a whole and from mixtures of beech and poplar in relation to pulps from pure beach and pure poplar. Work on the cooking of mixtures of species of tropical woods has been carried out in France[7, 9]. In these experiments mixtures of as many as ten species of woods from the forests of the Ivory Coast and the Gaboon with fibres of different characteristics were used for the digestion. The mixtures consisted of woods of different densities, e.g., light woods (density 0·2 to 0·25 gm./c.c.), medium woods (density 0·45 to 0·50 gm./c.c.) and very heavy woods (density 0·90 to 1·0 gm./c.c.); the fibres of these species varied in length from 1·15 to 3·0 mm. and in width from 0·015 to 0·060 mm. The results of these investigations showed that well-cooked pulps with satisfactory physical properties could be obtained by cooking a mixture of species if a careful selection was made of the various conditions of the cooking process such as the nature and quantity of chemicals, temperature, etc.

Since in some forests *Lannea grandis* occurs in mixed stands associated with species such as *Boswellia serrata* (*salai*), it was thought desirable to carry out the digestions of a mixture of this wood with *salai* and *Garuga pinnata* (*kharpat*). The chips of these three species were mixed in equal quantities and pulps were prepared by the semi-chemical process using 15% and 18% sodium sulphite ; in each case 25% of sodium carbonate (on the basis of the sulphite) was used. The digestion conditions, pulp yields and the strength properties of standard sheets made from these pulps are given in Table IV. For comparison, semi-chemical pulps by the neutral sulphite process using 18% sodium sulphite and 4·5% sodium carbonate were also prepared from pure *Boswellia serrata* and pure *Garuga pinnata*. The results of these digestions are also given in Table IV.

PRODUCTION OF CHEMICAL PULP

During the present century the pulp and paper industry has experienced an amazing growth not only in foreign countries but also in our own country. The supply of the more generally used raw material, viz., coniferous woods, for this industry in foreign countries is steadily decreasing. Hence attempts are being made to use more and more of woods of broad-leaved species for the production of paper. The poplar, birch, beech, etc., are used to some extent for pulping. Some species of Eucalyptus are used in Australia for this purpose. Bamboo and sabai grass (*Eulaliopsis binata*) are the chief raw materials in our paper industry. Conifers such as spruce and silver fir are found in the Himalayan region and these, when exploited, will be required for special kinds of paper such as newsprint. Our forests are full of broad-leaved species. To meet the growing need for raw materials in our paper industry, the utilization of broad-leaved woods provides one possible solution. It is true that the pulps from conifers, bamboos and some grasses are characterised by properties more suitable for paper than those from hardwoods. One such differentiation is the length of fibre, which for our hardwoods is about 0·8 to 1·2 mm. and for bamboo, 2·7 to 4·0 mm. ; this is responsible for the lower strength properties of papers from hardwoods. The fibre from broad-leaved trees has also a different structure from that of bamboos ; yet the soft and absorbent texture of the fibre from broad-leaved trees renders it useful for bulky papers such as certain kinds of printing papers. Admixture of bamboo or sabai grass should yield papers with suitable strength properties. Since *Lannea grandis* is available in forests near the Sirpur Paper Mills, Hyderabad, experiments on the production of chemical pulps from this species were carried out in this laboratory at the instance of these Mills.

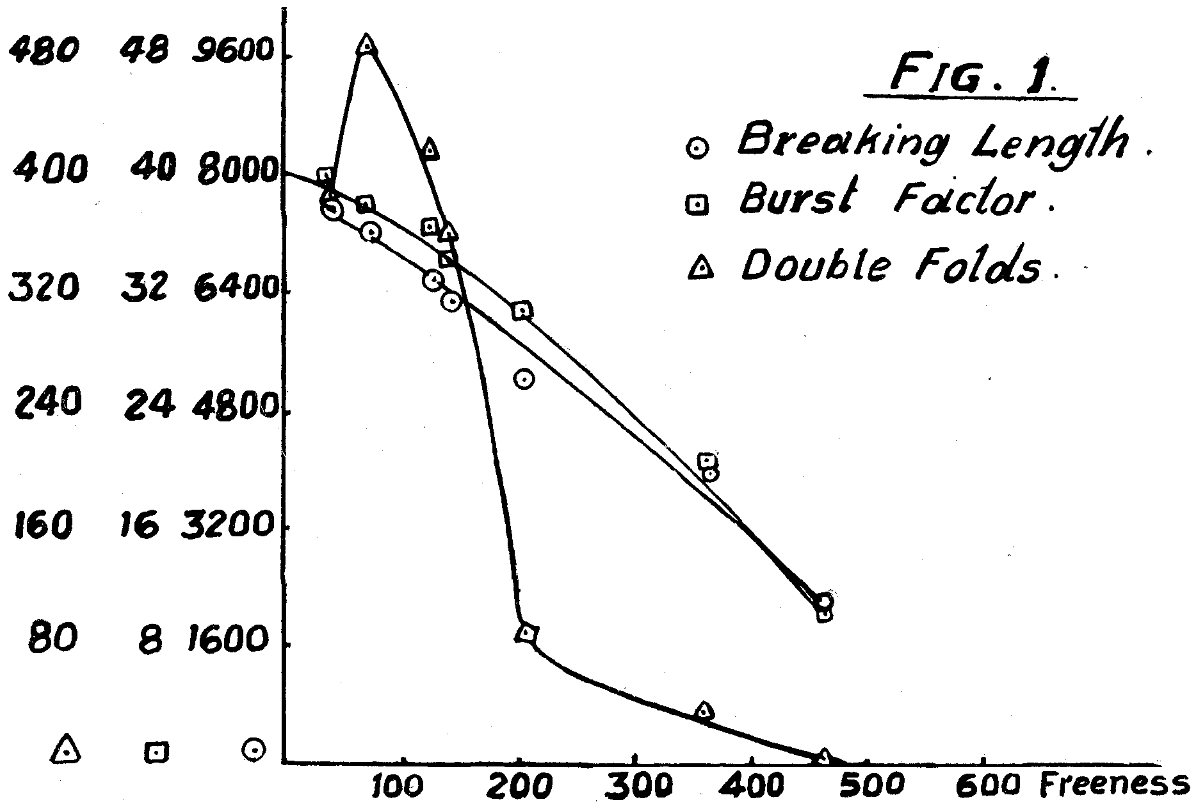

FIG. 1.
Breaking Length.
Burst Factor.
Double Folds.
480 48 9600
400 40 8000
320 32 6400
240 24 4800
160 16 3200
80 8 1600
100 200 300 400 500 600 Freeness

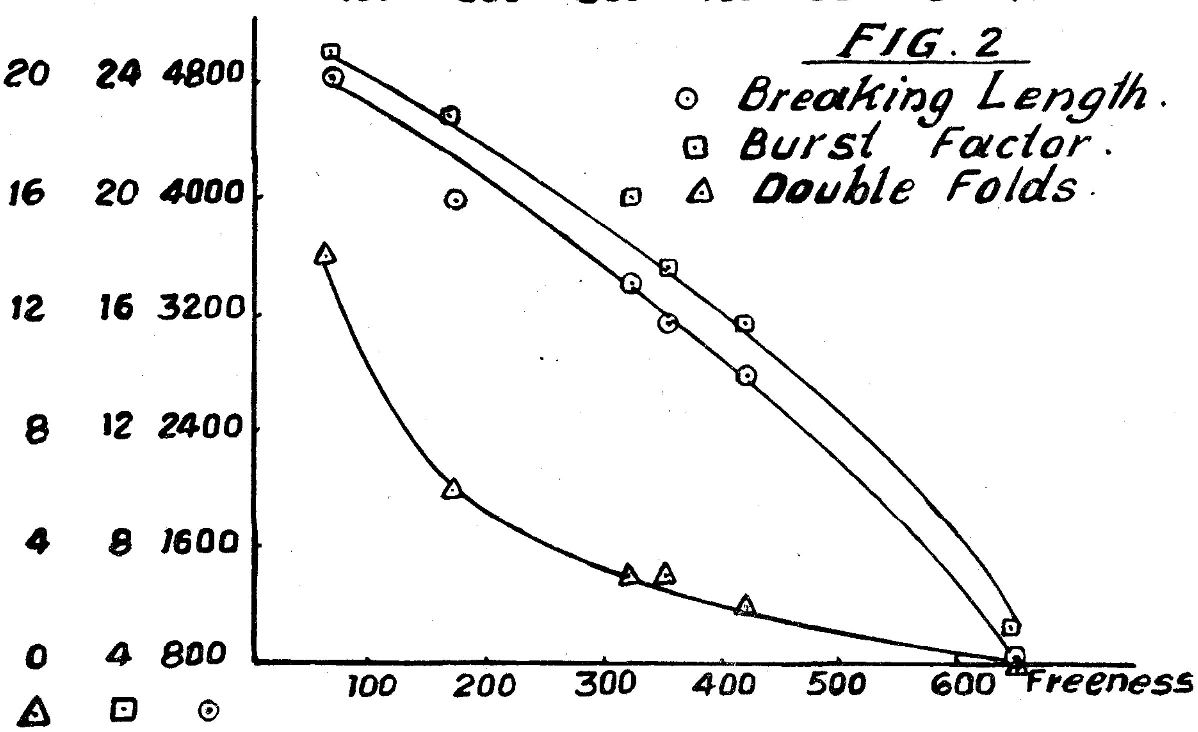

FIG. 2
Breaking Length.
Burst Factor.
Double Folds.
20 24 4800
16 20 4000
12 16 3200
8 12 2400
4 8 1600
0 4 800
100 200 300 400 500 600 Freeness.

A number of digestions were carried out by the sulphate process using caustic soda and sodium sulphide in the ratio 2 : 1. The quantity of total alkali was varied from 20 to 24% on the weight of the raw material, the temperature from 153° to 170°C and the period of cooking from 4 to 6 hours. The digestion conditions, pulp yields and strength properties of standard sheets from the chemical pulps of these experiments are given in Table V.

DISCUSSION

Semi-chemical Pulps.—It will be seen from the results recorded in Table II that the yields of the neutral sulphite semi-chemical pulps depend upon the conditions of the digestion. As would be expected, when lower quantities of chemicals are used and the digestion is carried out at comparatively lower temperatures, greater yields of pulps are obtained, but the strength properties are not as high as in the case of pulps obtained under more severe conditions. Under the conditions studied, the highest yield of the semi-chemical pulps was 77·8% and the lowest, 65·4% on the basis of the raw material. These yields are satisfactory for the production of wrapping papers. The colour of the pulps was brown and suitable for wrapping papers.

The pulps require to be beaten in order to develop their strength properties. In order to study the relation between the degree of beating and strength properties of the semi-chemical pulps, the breaking length, burst factor and double folds of semi-chemical pulps from Serial No. 3, Table II, were plotted against the freeness of the pulps (Fig. 1). The curves in Fig. 1 show that the breaking length and burst factor increase as the degree of beating is increased whereas the double folds increase slowly at first, then rapidly and finally decrease with the increase in beating beyond a certain limit. These observations are in conformity with known results regarding the relation between the degree of beating and strength properties of pulps.

From the foregoing it can be said that brown wrapping papers of suitable strength properties can be prepared by adjusting the conditions of digestion and beating of the semi-chemical pulps from *Lannea grandis*. If high strength properties are not essential, the digestion conditions given in Serial No. 1 experiment (Table II) are suitable for the production of cheap wrapping papers. In this case, the yield of the pulp is also quite good.

Results of the soda semi-chemical pulping recorded in Table III indicate that if high strength properties are not essential, wrapping papers in good yields can be prepared using caustic soda for the digestion. The colour of the pulps was brown and suitable for wrapping papers. This soda process can be utilized by paper mills which do not possess plants for the production of sodium sulphite. Besides, in these days of stock-piling, it is not easy to get sulphur for paper-making. The pulps from the soda semi-chemical process are poor in folding endurance compared with those from the neutral sulphite semi-chemical process. The breaking length, burst factor and double folds of soda semi-chemical pulps of Serial No. 5 (Table III) are plotted against freeness of the pulps in Fig. 2. These curves also show that these strength properties increase with increase in the degree of beating of the pulps.

Semi-chemical Pulps from Mixed Species.—By cooking a mixture of *Lannea grandis*, *Boswellia serrata* and *Garuga pinnata*, good homogeneous pulps were obtained. Although conclusions cannot be drawn from the results of one or two experiments, yet some interesting facts are revealed on comparing the strength properties of pulps of Serial No. 3*d*, Table II and Serial No. 2*b*, 3 and 4, Table IV. These pulps have nearly the same freeness. The breaking length of the pulp from pure *Lannea grandis* is the highest and that of the pulp from pure *Garuga pinnata* is the lowest. The breaking length of the pulp from the mixture containing

equal proportions of the three species named above is the mean of the breaking lengths of pulps from their pure woods. The bursting strength and folding endurance of the pulp from pure *Lannea grandis* is superior to those from pure *Boswellia serrata* and pure *Garuga pinnata*. The values for these strength properties of the pulp from the mixture of these three species fall between those of the pulps from the individual pure species. These results are in conformity with the findings of the French workers[8]. The stretch of the pulp from the mixture of these three species, however, is considerably higher than that of the pulps from the individual pure species. The tear is also similarly higher. The yield of pulp from the mixed species is the mean of the yields from the individual species. From the foregoing and the other results recorded in Table IV it can be said that neutral sulphite semi-chemical pulps suitable for wrapping papers can be prepared from a mixture of the woods of *Lannea grandis*, *Boswellia serrata* and *Garuga pinnata*.

Chemical Pulps.—From the results of the experiments on the chemical pulping of *Lannea grandis* recorded in Table V, it will be seen that the digestion of this wood by the sulphate process with 22% total alkali in 5% concentration at 153°C for 6 hours gives easy bleaching pulps with strength properties suitable for writing and printing papers. The yield of the bleached pulp under these conditions which is 46·2% on the weight of the raw material is satisfactory. If 20% total alkali is used, more bleaching powder is required for bleaching the unbleached pulp. If 24% total alkali is used, pulps with lower strength properties are obtained. Temperatures higher than 153°C yield pulps of lower strength properties. Since pulps from this species are short-fibred, admixture with long-fibred pulps from bamboo or sabai grass should be helpful in producing writing and printing papers of good strength properties. Pilot plant experiments on the production of writing and printing papers from *Lannea grandis* are in progress.

CONCLUSIONS

1. Semi-chemical pulps suitable for wrapping papers can be prepared by the neutral sodium sulphite process from *Lannea grandis*. The yield of pulp is 67–65% when 15–18% sodium sulphite is used. Semi-chemical pulps in higher yields (about 78%) but with lower strength properties can be prepared under milder conditions of digestion using as little as 6% of sodium sulphite.

2. Semi-chemical pulps suitable for wrapping papers can also be prepared using 10–12% caustic soda for the digestion. The yield of pulp is 64–74% under the conditions studied. These pulps have lower strength properties than the neutral sulphite semi-chemical pulps.

3. Semi-chemical pulps suitable for wrapping papers can be prepared by cooking a mixture of *Lannea grandis*, *Boswellia serrata* and *Garuga pinnata*. The yield of pulp is 64–65% under the conditions studied. The strength properties such as the breaking length, burst and folding endurance of these pulps are intermediate between those of pulps obtained by cooking these species separately under identical conditions. The stretch and tear values of these pulps are, however, slightly higher.

4. Easy bleaching chemical pulps suitable for writing and printing papers can be prepared from *Lannea grandis*.

Thanks are given to the Sirpur Paper Mills, Hyderabad, for the supply of *Lannea grandis* free of cost for these investigations.

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TABLE II—*Neutral sulphite semi-chemical pulps from*

Digestion Conditions and Pulp Yields								
1	2	3	4	5	6	7	8	9
	Chemicals for digestion*							
Serial No.	Sodium sulphite	Sodium carbonate	Material : Liquor ratio	Digestion temperature	Digestion period	Pulp yield*	Freeness	Drainage time
	%	%		°C	hours	%	c.c. (C.S.F.)	seconds
1*a*	6	1·5	1 : 4	121° for the 1st two hours and 142° for the remaining period	5	77·8	182	6
1*b*	,,	,,	,,	,,	,,	,,	73	10
2*a*	15	3·75	1 : 4	170°	3	67·1	450	6
2*b*	,,	,,	,,	,,	,,	,,	200	12
3*a*	18	4·5	1 : 3·5	170°	3	65·4	462	6
3*b*	,,	,,	,,	,,	,,	,,	359	7
3*c*	,,	,,	,,	,,	,,	,,	203	8
3*d*	,,	,,	,,	,,	,,	,,	138	9
3*e*	,,	,,	,,	,,	,,	,,	124	10
3*f*	,,	,,	,,	,,	,,	,,	68	12
3*g*	,,	,,	,,	,,	,,	,,	37	22

* The % is expressed on the weight of the raw material (air-dry).

Lannea grandis and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 70% R.H. AND 82° F.

10	11	12	13	14	15	16
Basis weight	Breaking length	Stretch	Tear factor (Elmendorf)	Burst factor (Ashcroft)	Double folds (Schopper)	Remarks
gms./sq. metre	metres	%				
60·8	4340	2·4	52·3	21·8	12	Defibrated for 15 minutes before beating in the Lampen Mill. The colour of the pulps of Serial Nos. 1–3 was brown.
61·2	4142	2·2	51·2	18·9	10	,, ,, ,, ,,
61·6	1732	..	55·2	13·6	5	Not beaten after defibration for 7½ minutes.
60·8	6169	..	88·8	40·3	693	Defibrated for 7½ minutes and beaten in the Lampen Mill.
60·8	2288	2·2	47·8	10·5	5	Defibrated for 7½ minutes but not beaten.
60·4	4061	2·4	68·8	20·8	36	The pulps in 3*b*–3*g* were all defibrated for 7½ minutes and beaten in the Lampen Mill to different degrees of freeness.
59·6	5282	2·6	79·2	31·1	88	
60·9	6371	2·8	78·8	34·4	363	
59·5	6608	2·8	78·8	36·5	421	
60·4	7244	2·8	78·4	38·1	493	
59·7	7568	2·8	78·0	40·2	385	

TABLE III—*Soda semi-chemical pulps from Lannea*

Digestion Conditions and Pulp Yields								
1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali	Digestion temperature	Digestion period	Pulp yiled*	Freeness	Drainage time	Basis weight
	%	%	°C	hours	%	c.c. (C.S.F.)	seconds	gms./sq. metre
1*a*	10	3	142	3	73·8	302	6	60·8
1*b*	,,	,,	,,	,,	,,	280	6	61·2
2*a*	12	3	142	3	64·6	306	6	62·6
2*b*	,,	,,	,,	,,	,,	253	6	60·4
3*a*	10	3	142	3	73·6	303	6	61·2
3*b*	,,	,,	,,	,,	,,	268	6	59·4
4*a*	12	3	142	3	64·8	342	6	60·8
4*b*	,,	,,	,,	,,	,,	232	6	62·4
5*a*	10	3	142	3	73·5	650	5	63·0
5*b*	,,	,,	,,	,,	,,	421	6	59·2
5*c*	,,	,,	,,	,,	,,	352	6	60·6
5*d*	,,	,,	,,	,,	,,	322	7	62·8
5*e*	,,	,,	,,	,,	,,	170	8	61·8
5*f*	,,	,,	,,	,,	,,	62	10	58·8

* The % is expressed on the weight of the raw material (air-dry).

grandis and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 70% R.H. AND 82° F.

10	11	12	13	14	15
Breaking length	Stretch	Tear factor (Elmendorf)	Burst factor (Ashcroft)	Double folds (Schopper)	Remarks
metres	%				
4028	2·1	52·8	20·1	4	Defibrated in the Asplund defibrator for 7½ minutes before beating in the Lampen Mill. The colour of the pulps in Serial Nos. 1–5 was brown.
4348	2·2	50·2	22·8	7	
5280	2·3	50·2	17·8	16	
5342	2·5	48·2	19·8	30	,, ,,
3531	2·0	44·2	15·2	2	Kollerganged for 15 minutes in the factory Kollergang and then beaten in the laboratory Kollergang.
3820	2·1	42·3	16·8	3	
4230	2·1	43·6	18·9	5	
4640	2·2	40·1	21·0	6	,, ,,
860	0·3	20·2	5·2	0	Kollerganged for 15 minutes in the factory Kollergang and then beaten in the Lampen Mill.
2800	1·4	40·8	15·8	2	
3150	1·8	40·0	17·8	3	
3430	2·0	39·8	20·2	3	
4010	2·2	39·8	22·9	6	
4850	2·5	39·0	24·9	14	

TABLE IV—*Neutral sulphite semi-chemical pulps from the cooking of mixed woods of Lannea corresponding data for the semi-chemical pulps from Boswellia serrata*

DIGESTION CONDITIONS AND PULP YIELDS							
1	2	3	4	5	6	7	8
Serial No. and species used	Chemicals for digestion*		Material : Liquor ratio	Digestion temperature	Digestion period	Pulp yield*	Freeness
	Sodium sulphite	Sodium carbonate					
	%	%		°C	hours	%	c.c. (C.S.F.)
1*a* } Mixture of *L. grandis*, *B. serrata* and *G. pinnata*	15	3·75	1 : 4	170°	3	65·2	470
1*b*	,,	,,	,,	,,	,,	,,	186
1*c*	,,	,,	,,	,,	,,	,,	95
2*a*	18	4·5	1 : 4	170°	3	63·8	404
2*b*	,,	,,	,,	,,	,,	,,	173
2*c*	,,	,,	,,	,,	,,	,,	83
3 (*B. serrata*)	,,	,,	1 : 3·5	,,	,,	60·2	142
4 (*G. pinnata*)	,,	,,	1 : 4	,,	,,	65·2	140

* The % is expressed on the weight of the raw material (air-dry).

grandis, Boswellia serrata and Garuga pinnata and strength properties of standard sheets. The (salai) and Garuga pinnata (kharpat) are included for comparison

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 70% R.H. AND 82° F.

9	10	11	12	13	14	15	16
Drainage time	Basis weight	Breaking length	Stretch	Tear factor (Elmendorf)	Burst factor (Ashcroft)	Double folds (Schopper)	Remarks
seconds	gms./sq. metre	metres	%				
6	60·9	1191	3·0	28·4	7·7	3	In Serial Nos. 1 and 2, *jhingan*, *salai* and *kharpat* chips were mixed in equal proportions by weight and then digested. Defibrated in the Asplund Defibrator for 7½ minutes before beating in the Lampen Mill. The colour of pulps was brown.
7	61·3	4320	4·5	74·6	25·1	46	
12	59·8	4761	4·8	70·2	29·3	246	
6	61·2	1695	3·4	48·2	9·2	4	
7	60·8	5052	4·5	85·2	30·1	164	
12	61·0	5819	4·8	79·4	35·6	881	
8	60·4	5086	2·8	63·8	25·0	63	In Serial No. 3 only *salai* chips were used for the digestion and in Serial No. 4 only *kharpat* chips were used. The mechanical treatment in both these cases was the same as in Serial No. 2. The colour of the pulps was brown.
7	60·8	3756	3·6	79·6	21·9	84	

TABLE V—*Sulphate digestions of Lannea grandis*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH*	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption*	Bleached pulp yield*
	%	%	°C	hours	%	%	%	%
1	20	4	170°	4	19·8	49·8	11·6	43·4
2	20	5	153°	6	19·8	49·3	11·3	44·0
3	20	5	162° for the first hour and 153° for the remaining period	6	19·8	49·3	11·2	43·8
4	22	5	153°	6	20·7	49·1	8·0	46·2
5	22	5	162°	5	20·8	48·7	8·7	44·8
6	24	5	153°	6	20·8	47·2	8·7	44·4
7	24	5	170°	4	21·6	44·2	8·1	41·8

* The % is expressed on the basis of the raw material (air-dry).

and strength properties of standard sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 70% R.H. AND 82° F.

10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Elmendorf)	Burst factor (Ashcroft)	Double folds (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metre	metres	%				
315	60·8	6857	4·1	87·2	40·3	480	
316	64·0	6732	4·5	87·5	40·3	1380	
308	56·8	6684	4·5	83·3	39·8	1231	The pulps in Serial Nos. 1–7 were well cooked.
318	62·1	6667	4·2	72·6	47·4	272	
290	60·0	5994	4·0	66·6	29·2	128	
348	58·2	4368	3·0	58·2	30·6	32	
300	61·0	4253	3·5	47·5	23·0	21	

ESTIMATION OF SANTONIN IN ARTEMISIA SPECIES

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Certain modifications have been introduced in the method of Massagetow for the assay of artemisias for santonin. The modified method gives better results than the original method or the commonly adopted method of Fromme.

Santonin is one of the most important and costly medicines derived from the vegetable kingdom. It is largely used to remove roundworms (*Ascaris lumbracoides*) from the intestines. Russian Turkestan was the sole source of supply of this important anthelmintic, but in the twenties of the present century santonin-yielding artemisia was found and exploited in the Kurrum Agency and in Kashmir. This was an important development, since, besides breaking the monopoly of Russian Turkestan, India started manufacturing the drug to the extent of over a million rupees worth annually and also exported some of the raw material to the United Kingdom. The plants yielding santonin in India are *Artemisia maritima* Linn., forma *rubricaule* Badhwar (Kurrum artemisia) and *A. brevifolia* Wall. (Kashmir artemisia).

After the partition of India in 1947, Kurrum Agency has gone over to Pakistan and most of the Kashmir artemisia area is situated beyond the present cease-fire line, which is occupied by Pakistan troops. The Indian santonin factories are thus unable to procure adequate quantities of suitable raw material.

Large quantities of *A. brevifolia* are known to be growing in the Himalayas, particularly in Lahoul, Pangi, Jammu, Kanawar and Jaunsar. But it is the authors' experience that only some forms of this species at certain stages of growth contain commercially exploitable amounts of santonin ; others contain either little or no santonin at all and are, therefore, useless from the practical point of view. With a view to finding santonin-rich forms well within the present Indian boundaries the authors have started a systematic investigation of the artemisia areas and the forms growing therein. Some of the forms collected from Lahoul have for the first time been found to yield as much as 2 per cent santonin on air-dry basis. This compares favourably with Kurrum and Kashmir artemisias. There are, however, several forms in the same area, which contain little or no santonin at all. Numerous samples from this area are being examined and only after all of them have been investigated will it be possible to state whether Lahoul artemisia is commercially exploitable or not.

Since investigation of this problem involves the examination of an extraordinarily large number of samples, we have felt the need for a simple, rapid and yet reliable method of assay without the use of large volumes of costly solvents.

Although several methods, gravimetric, volumetric and polarimetric, have been suggested for the estimation of santonin in artemisia, none of them is found completely satisfactory. Amongst the gravimetric methods, which are more commonly used almost to the exclusion of the others, the method of Fromme (Engelhardt and O'Brian[1]) is the most widely employed. This method consists in extracting the plant material with chloroform and isolating santonin by way of the barium salt. The liberated santonin from Indian samples of artemisia is, however, almost always contaminated with large amounts of resinous impurities, so that, for the isolation of the pure drug, washing off the resins by means of ammonia has

been suggested[2]. In spite of this modification, crystallization from a large volume of alcohol is also necessary to obtain santonin in a pure state. To make up for the loss of dissolved santonin in the alcoholic mother liquor, a correction factor has to be applied. Although it is possible to obtain reasonably accurate results by this method in the case of samples of artemisia containing 2 to 3 per cent of santonin, it is to be realized that in the case of low-grade artemisias the correction factor may be sometimes as high as the amount of santonin actually recovered in the assay. Several investigators have attempted to rectify this defect without much success[3,4,5].

After a critical examination of the several methods, we have found that the method of Massagetow[6] with certain modifications gives quite accurate and reliable results even with low-grade artemisias. It is also rapid and does not require large volumes of costly solvents. The method, which is akin to the industrial process[7] of extraction of santonin from the raw material, consists in (*a*) boiling the crude drug with limewater, (*b*) acidifying the lime extract, (*c*) extracting the liberated santonin with chloroform, (*d*) removing the resins and other impurities by washing with 4 per cent aqueous alkali and by treatment with animal charcoal, (*e*) distilling off the chloroform and (*f*) finally crystallizing the residue. On a detailed study of this method, we have found that animal charcoal treatment, even when applied in the cold as suggested by Massagetow[6], effects a definite loss of the recoverable santonin. The loss is neither negligible nor consistent, as shown in the following table, to apply any correction factor.

TABLE

Serial number	Amount of santonin taken in 100 c.c. of chloroform (mg.)	Weight of animal charcoal added (g.)	% loss
1	20	0·1	4·5
2	40	0·2	6·0
3	50	0·2	4·0
4	148	0·2	7·3
5	234	0·2	5·4

It is, therefore, desirable that treatment with animal charcoal be altogether avoided. In order to completely remove the colour and the resinous impurities without resorting to animal charcoal treatment, it has been found that a second washing with 4 per cent alkali is quite effective and sufficient. It has been further established that washing with 4 per cent alkali does not effect any loss of santonin from the chloroform solution.

With a view to reducing the amount of solubility correction at the stage of crystallization, several experiments have been carried out to determine the minimum volume of the solvent necessary for proper crystallization. While incidentally confirming the correction factor suggested by Massagetow, namely 0·0002 g. per c.c., it has been found that the final volume of crystallization can be reduced to about 45 c.c., instead of 60 c.c., as recommended in the original method.

A modification has also been now introduced at the final stage of weighing of the isolated santonin. Massagetow prescribes dissolving the isolated crystals in chloroform, transferring the solution into a weighed flask, driving off the solvent, and weighing the residue

after drying. It has been found that the crystals can be conveniently filtered into a tared filter paper, dried at 100°C and weighed after cooling.

Incorporating the changes mentioned above, the method of assay runs as follows :—

Triturate 5 g. of the sample (artemisia), powdered to 40 mesh, with 1 g. of calcium oxide and 10 c.c. of hot water. Boil the mixture with 250 c.c. of water for 10 minutes, filter and wash the residue with a further quantity (250 c.c.) of boiling water. Acidify the warm filtrate with 20 c.c. of concentrated hydrochloric acid and keep it for 5 minutes on a boiling water bath. Extract the solution, after cooling, successively with 50, 30, 20 and 20 c.c. of chloroform. Wash the combined chloroform solution twice with 4 per cent sodium hydroxide, taking 30 c.c. each time to remove the colour and resinous impurities, and then with 20 c.c. of water to remove the alkali. After distilling off the solvent, dissolve the residue in 2 c.c. of alcohol and add 100 c.c. of boiling water. Boil down the solution to 45 to 50 c.c. and keep overnight. Collect the separated crystals of santonin into a tared filter paper, dry at 100°C for 40 minutes, cool and weigh. Add a correction of 0·0002 g. per c.c. for the santonin dissolved in the filtrate. The total weight multiplied by 20 gives the percentage of santonin in the sample.

The following are some of the typical analyses of the drug, when analyzed according to the above method. For the sake of comparison, the results obtained by Fromme's method and also by the original method of Massagetow are also included.

SANTONIN RECOVERED

Sample number	By Massagetow's method (original) (%)	By Massagetow's method as modified by the present authors (%)	By Fromme's method (%)
1	0·91	0·98	0·98
2	1·42	1·45	1·29
3	..	1·63	1·56
4	..	1·90	1·81
5	1·77	1·83	1·75
6	0·92	0·94	0·87
7	0·66	0·69	0·64

Samples of santonin as isolated by the present method of assay are quite crystalline and pure, melting at 168–70°C.

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DIFFUSION IN WOOD

I. Diffusion of ions through some Indian Timbers

BY D. NARAYANAMURTI, V. RANGANATHAN* AND R. S. RATRA

SUMMARY

A simple diffusion cell (which can be easily constructed from perspex sheeting) for studying the passage of molecules, ions, gases, vapours and liquids through wood and other membranes is described.

The diffusion of ions through some species of Indian timbers under a variety of conditions has been studied and the results reported.

The results show that the diffusion of ions through wood obeys Fick's law as long as the ion does not react with any constituents of the wood. In other cases there is deviation from this law. The diffusion constant is largest in the axial direction and smallest in the tangential direction. As against other claims, for the species tested, ionic diffusion is higher through sapwood than through heartwood. Temperature increases the rate of diffusion of ions. Diffusion of copper sulphate through cellophane is in conformity with Fick's law and is of the same order as for some timbers.

Diffusion processes play an important part in various timber industries, e.g., the treatment of veneers with resins or resin forming systems, preservatives like boric acid, etc. For efficient treatment it is essential that the fundamental laws governing the movement of ions, molecules, etc., through wood are established. A knowledge of these factors is also of interest to the wood seasoning, textile, leather, and paper technologists and the plant physiologist.

While the diffusion of moisture through wood has been the subject of study by a number of investigators (*vide* Martley, 1926 ; Kollmann, 1935 ; Egner, 1934 ; Narayanamurti, 1935) ; the movement of other molecules and ions has not been the subject of such extensive studies.

Cady and Williams (1935) studied the diffusion of urea, glycerol and lactose into several species of water-saturated soft-woods relative to their diffusion in water. More recently the diffusion of salts through green timber has been extensively studied by Christensen in Australia. He developed a diffusion cell, which, in essentials, consisted of two glass bottles with one vertical face completely ground away. Between these two faces (which formed the flanges of the diffusion cell) covered with rubber gaskets the wood membrane was placed. The cell was held together with four clamps.

Christensen for most of his studies, used *Eucalyptus* wood and metallic chlorides. He investigated the validity of Fick's law and the influence of factors like temperature, direction of diffusion, type of ion, etc. While the results obtained with alkali metal chlorides were in conformity with Fick's law, they were not so with salts like zinc chloride. Christensen attributes this to the precipitation of the tannins in the wood. He is also of opinion that probably there is no great difference in the diffusion of salts through sapwood and heartwood.

Theoretical.—Fick's law of diffusion can be mathematically expressed as follows :—

$$q = k \frac{dc}{dx} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1).$$

where q is the quantity of the substance flowing through in gms/cm^2 sec., k the diffusion constant and $\frac{dc}{dx}$ the concentration gradient. k has the dimensions $\frac{cm^2}{sec.}$ This applies to

capillary systems. In the case of space energy systems (pores of molecular dimensions) the concentrations at the two surfaces of the membrane are not the same as that in the reservoir and a relation between reservoir and surface concentrations depending on a Henry distribution exists and $\frac{dc}{dx} = T \frac{dc^1}{dx}$, where T is the distribution coefficient.

Apparatus.—The apparatus employed is shown in Figs. 1 and 2. In essentials it consists of 2 chambers made from perspex sheeting with flanges, between which the specimen under investigation is fixed, rubber washers being used between the flanges and the specimen. The effective area of the specimen was usually 36 cm^2 (6 cm $\times$ 6 cm.). The top of the two halves of the diffusion cells were provided with two holes for receiving or emptying the solution or water used in the cells. These were stoppered with a fine capillary to avoid evaporation during the test.

The specimen was placed between the flanges of the cell and the whole assembly was held in a wooden frame fitted with nuts and bolts. Rubber packing between the cell walls and wooden frame helped to prevent damage to the cells.

Materials and preparation of the specimens.—The choice of species for the experiments was mainly controlled by availability. *Canarium strictum* (*dhup*) and *Cullenia excelsa* (*karani*) were used for a majority of the experiments. *Canarium strictum* (*dhup*) is a hardwood, not heavily tylosed. The grain is interlocked. *Cullenia excelsa* is a straight grained and medium textured hardwood. Tyloses are fairly abundant though not occluding the pores. Other timbers studied in a small way included sal (*Shorea robusta*) *salai* (*Boswellia serrata*), *semul* (*Bombax malabaricum*), *vellapine* (*Vateria indica*), and *haldu* (*Adina cordifolia*).

In the case of the first two species, and *Vateria indica* specimens were prepared (*vide* maps 1 to 3) from different locations in 8″ thick discs of the timbers. In the case of the other species, specimens were taken from material available.

The specimens were cut and planed to the size required and were kept under water till wanted for use. Before fitting in the cells, the outer half-inch edges of the specimens were given three coats of shellac varnish to prevent end leakage. They were further given a coat of paraffin and in other cases thin aluminium foil was used.

In addition to wood, cellophane was also studied.

Chemicals studied.—In the preliminary experiments sodium chloride was used. Other substances used were :—mercuric chloride, boric acid, sodium fluoride, copper sulphate, potassium dichromate, arsenic acid and Ascu.

Measuring equipment.—The ions were estimated according to standard practice. Sodium fluoride and boric acid were estimated interferometrically.

Procedure of carrying out the tests.—After installation of the test specimen in the diffusion cell both compartments of the cell were first filled with distilled water and kept in the thermostat for a day, the next day the cells were emptied and then one side was filled with distilled water and the other side with the solution of the salt. It is necessary, especially with axial specimens, to pour both the solution and water at the same time and at the same rate. The holes in the top were lightly corked and the cells kept in an air thermostat.

At intervals of 24 hours the cells were emptied (again care being taken to empty both sides simultaneously and at the same rate) and the contents analysed. This was continued till the steady state was reached.

Accuracy of the experiments.—It is estimated that the accuracy of the diffusion constants can be taken as better than $\pm$ 5%.

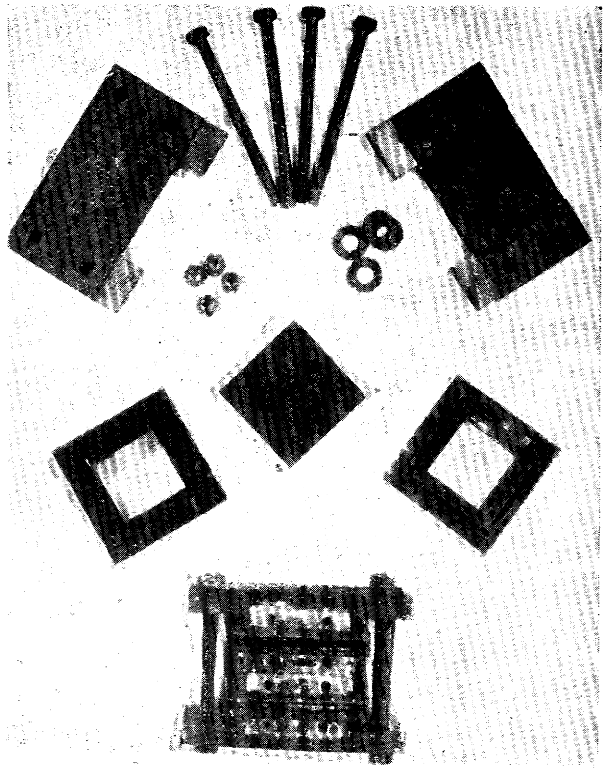


FIG. 1.

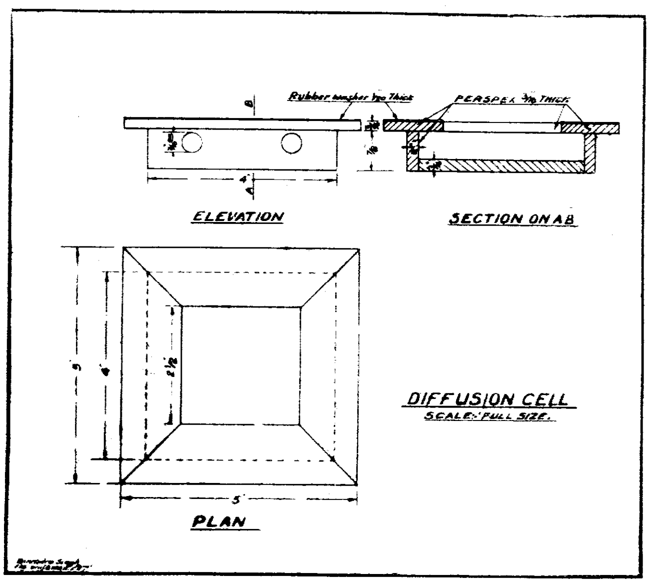


FIG. 2.

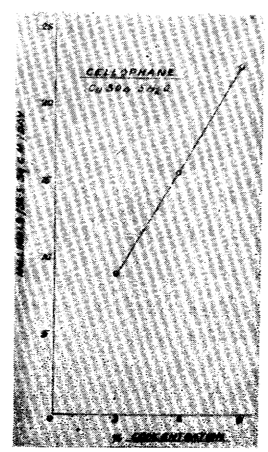


FIG. 4.

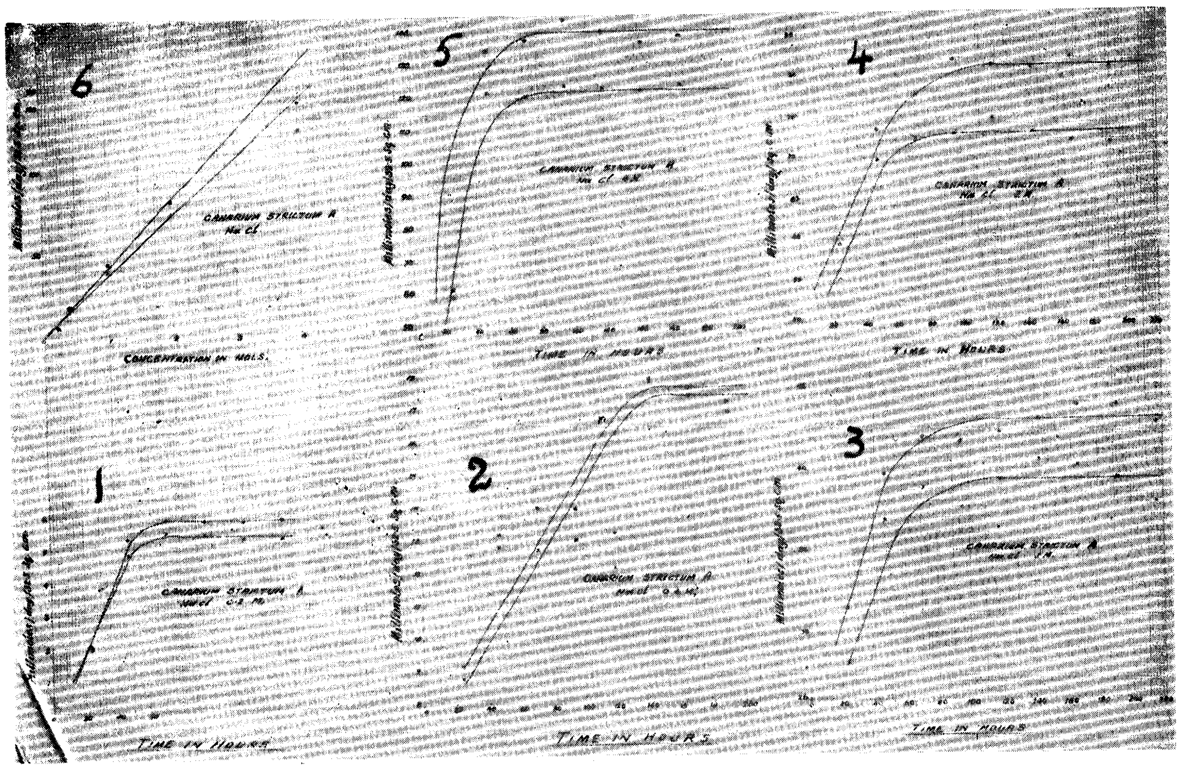
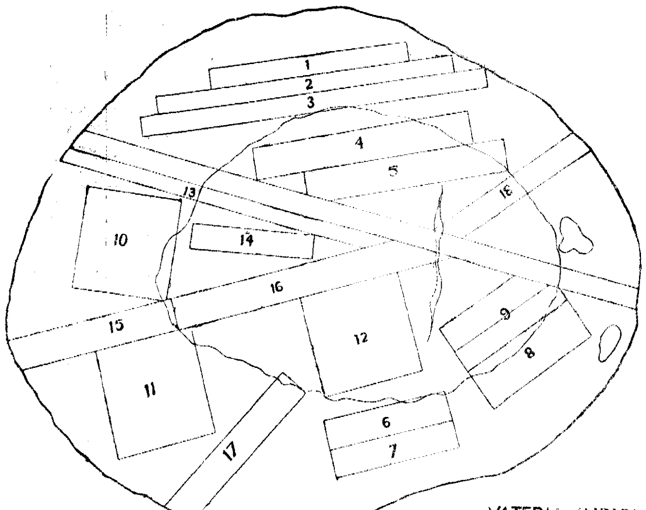
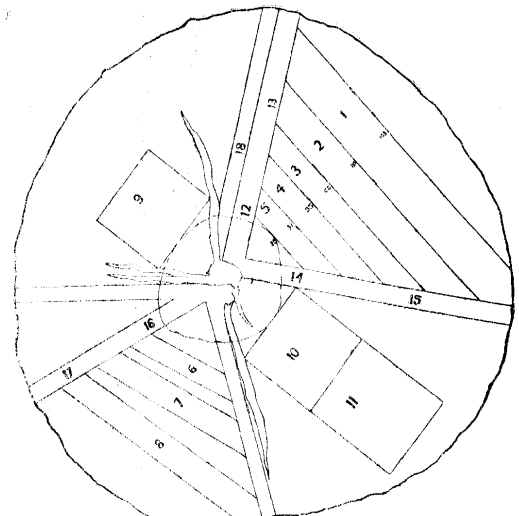

6
5
4
1
2
3
CONCENTRATION IN MOLS.
TIME IN HOURS
TIME IN HOURS
TIME IN HOURS
TIME IN HOURS
TIME IN HOURS

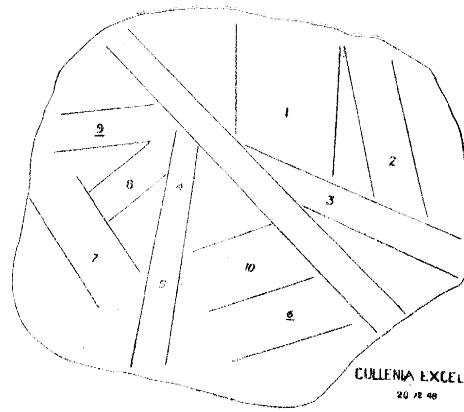
FIG. 3.



VATERIA INDICA



CANARIUM STRICTUM



CULLENIA EXCELSA
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Evaluation of results.—From the analytical and other data the diffusion constant was calculated according to equation (1). As an example, the data for *Canarium strictum* (axial specimen) and sodium chloride is given below :—

Effective area of the specimen .. .. .. $32 \cdot 5$ c.m.^{2}
Difference in concentration between the two faces of the specimen .. .. 1 m. mole/cm.^{3}
Thickness of the specimen .. .. .. $1 \cdot 241$ cm.
Quantity of sodium chloride flowing through the specimen Q $9 \cdot 15$ millimols/day.
Diffusion constant calculated according to the equation :

$$K = Q \times \frac{dx}{dc}\,\frac{1}{F} = 9 \cdot 15 \times \frac{1 \cdot 241}{1} \times \frac{1}{32 \cdot 5} \times 1.$$
$$= 0 \cdot 349 \text{ cm}^2/\text{day at } 30°\text{C}.$$

RESULTS AND DISCUSSION

Experiments with sodium chloride.—The earliest experiments were done with sodium chloride for the following reasons :—

(1) It is not precipitated by the constituents of wood,
(2) For comparison with Christensen's results.

Fig. 3 shows the time taken to reach the steady state.

Effect of concentration of the salt on the diffusion constant.—Table I gives the values of the diffusion constant for *Canarium strictum* in the axial direction. The agreement between duplicates is satisfactory. The diffusion coefficient is within the limits of experimental error independent of the cocentration gradient excepting for the lowest and highest gradients. In the former case the rather low values may be due to the low amounts diffusing through, with consequent inaccuracies in determination, and in the latter case the large amounts diffusing through and thus bringing the real gradient to less than $4 \cdot 0$ and also to the noticeable osmotic effects in this case.

TABLE I

Diffusion of sodium chloride

Effect of increasing concentration gradient. *Canarium strictum*, axial flow.
Effective area $32 \cdot 5$ sq. cm. Temperature 30°C.

Specimen No. and thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.^{2}/day
1	2	3	4
I (10)	0·2	1·22	0·233
1·241	0·4	3·67	0·350
	1·0	9·15	0·349
	2·0	17·06	0·326
	4·0	29·48	0·281
			Mean = 0·308
II (10)	0·2	1·29	0·229
1·156	0·4	4·27	0·38
	1·0	9·81	0·349
	2·0	18·01	0·320
	4·0	30·05	0·267
			Mean = 0·309

TABLE IA

Diffusion of sodium chloride

Concentration difference one mol.

Species	Direction of flow	Effective area sq. cm.	Thickness cm.	Temperature °C	Quantity flowing/day in mollimols	K × 10³ cm.²/day
Boswellia serrata ..	Radial	32·5	0·156	30	0·278	1·33
Shorea robusta ..	Tangential	40·32	0·16	33	16·2	64·3

Influence of the sodium chloride content in wood on the diffusion.—As is well known the diffusion constant (below the fibre saturation point) for moisture in wood (*vide* Martley, Egner, Narayanamurti) increases with the moisture content up to the fibre saturation point. Neale *et al* (1938) found similar behaviour for the diffusion of dyestuffs in cellulose. To see whether salts also behave similarly the gradient of sodium chloride was kept constant but the concentrations at the two faces of the specimen were gradually increased. From the results given in Table II below it will be seen that unlike the diffusion of moisture in wood the diffusion of salt is independent of the salt content in the axial direction as far as sodium chloride is concerned.

TABLE II

Diffusion of sodium chloride

Effect of constant gradient, *Canarium strictum*, axial flow

Effective area 32·5 sq. cm. Temperature 30°C.

Specimen No. and thickness cm.	Concentration Mols/litre Higher	Lower	Quantity flowing Millimols/day	K cm.²/day
1	2		3	4
I (10) 0·745 ..	1·0	0·5	9·98	0·458
	1·5	1·0	9·75	0·447
	2·0	1·5	9·64	0·442
	2·5	2·0	10·15	0·465
				Mean = 0·453
II (10) 0·698 ..	1·0	0·5	11·4	0·490
	1·5	1·0	10·88	0·467
	2·0	1·5	10·0	0·430
	2·5	2·0	11·12	0·478
				Mean = 0·466

Influence of thickness.—To investigate the influence of thickness the same specimen was used for all the four thicknesses investigated. At the end of the experiment with the largest thickness the specimen was planed down to the next thickness, this procedure being repeated for the other thicknesses. A molar concentration difference was maintained between the two sides of the specimen. Table III shows the validity of Fick's law.

TABLE III

Diffusion of sodium chloride

Effect of thickness. Temperature 30°C

Canarium strictum, axial flow. Effective area 32·5 sq. cm.

Concentration difference 1·0 mol./litre

Specimen No.	Thickness cm.	Quantity flowing millimols/day	K cm.^{2}/day
I (10)	1·241	9·15	0·349
	1·146	10·33	0·364
	0·958	12·12	0·357
	0·745	16·23	0·372
			Mean = 0·361
II (10)	1·156	9·81	0·349
	1·054	11·13	0·361
	0·884	12·95	0·352
	0·698	18·27	0·392
			Mean = 0·363

Results with other species and comparison with the results of other investigators.—The diffusion of sodium chloride through (*Boswellia serrata* (*salai*) in the radial direction was investigated and the results are given at the foot of Table I.

Christensen obtained a diffusion constant of $3\cdot38 \times 10^{-3}$ cm^2/day at 70°F and $6\cdot84 \times 10^{-3}$ cm^2/day at 110°F for *Eucaluptus obliqua* across the grain, no results for diffusion along the grain being available. *Salai* appears to be less permeable than *Eucalyptus.*

Influence of the type of ion diffusing.—Christensen who was mainly working with chlorides found that in cases where the solution reacted with the wood constituents, the results were not in conformity with Fick's law. Our results with copper sulphate, potassium dichromate, arsenic acid and Ascu are given below :

Copper sulphate.—The results are given in tables IV and V. The results for axial flow are irregular and show wide variation with different concentration gradients. Whether this is due to precipitation, swelling, adsorption, pH changes, etc., that may be caused, only further experiments can show. In the case of tangential flow the constants agree within 15% in one case and 7% in the other. The variation is higher for radial flow.

TABLE IV

Diffusion of copper sulphate at 30°C

Effect of increasing concentration gradient

Canarium strictum, Axial flow. Effective area 36 sq. cm.

Specimen No. and thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.^{2}/day
I (11) 1·27	0·04	0·537	0·474
	0·12	4·2	1·235
	0·24	3·56	0·523
	0·36	11·28	1·105
			Mean = 0·834

(*contd.*)

TABLE IV—(*concld.*)

Specimen No. and thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.²/day
II (10) 1·27	0·04	Nil	Nil
	0·12	0·133	0·039
	0·24	0·212	0·031
	0·36	1·146	0·112
			Mean = 0·046
III (9)	0·04	0·094	0·0398
Unleached	0·12	0·430	0·0607
0·61	0·24	0·939	0·0663
	0·36	2·854	0·134
			Mean = 0·0752

TABLE V

Diffusion of copper sulphate at 30°C

Effect of increasing concentration gradient

Species :—*Canarium strictum.* Effective area 36 sq. cm.

Specimen No. and direction of flow	Thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.²/day
Radial I	0·128	0·04	Nil	Nil
(3)	0·128	0·12	0·0064	0·00019
	0·128	0·24	0·009	0·00013
	0·128	0·36	0·0115	0·00011
				Mean = 0·00011
Radial II	0·16	0·04	Nil	Nil
(4)	0·16	0·12	0·0063	0·00023
	0·16	0·24	0·008	0·00015
	0·16	0·36	0·015	0·00019
				Mean = 0·00014
Radial III	0·16	0·04	0·00355	0·00039
(7)	0·16	0·12	0·0062	0·00023
Unleached ..	0·16	0·24	0·0082	0·00015
	0·16	0·36	0·0111	0·00014
				Mean = 0·00023
Tangential I	0·156	0·04	Nil	Nil
(12)	0·156	0·12	0·0039	0·00014
	0·156	0·24	0·0065	0·00012
	0·156	0·36	0·0105	0·00013
				Mean = 0·00010
Tangential II ..	0·169	0·04	Nil	Nil
(15)	0·169	0·12	0·004	0·00016
	0·169	0·24	0·0086	0·00017
	0·169	0·36	0·0119	0·00016
				Mean = 0·00012

The closer agreement for tangential flow may be due to the extremely low permeability of these specimens. The unleached specimen for radial flow, however, shows erratic results, the diffusion constant decreasing with increasing gradient. Possible reaction of the solution with wood constituents may be one of the major causes of this deviation from Fick's law. Stiles (1920) also found that the diffusion coefficient decreases with concentration of reacting ions in gels.

This is further strengthened by results obtained with cellophane in place of wood. The results are represented in Fig. 4. The constancy of the diffusion coefficient is good. Cellophane is more permeable than *Canarium* across the grain.

Potassium dichromate.—The results are given in tables VI and VII. With *Canarium* sp. and axial flow in the heartwood, excepting the lowest concentration, the other three agree within 30%. With sapwood the agreement is more satisfactory. With *Cullenia excelsa* in some cases there is good agreement, in others, not. The erratic behaviour is possibly due to the reaction and precipitation of chromium.

TABLE VI

Diffusion of potassium dichromate at 30°C

Canarium strictum, axial flow

Effective area 32·5 sq. cm.

Specimen No. and thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.^{2}/day
I (10) 1·299	0·017	0·0004	0·0094
	0·034	0·031	0·036
	0·068	0·0997	0·059
	0·136	0·115	0·034
			Mean = 0·0346
II (11) 1·287	0·017	0·112	0·261
	0·034	0·257	0·299
	0·068	0·59	0·344
	0·136	1·06	0·309
			Mean = 0·303

TABLE VII

Diffusion of potassium dichromate at 30°C

Effect of increasing concentration gradient

Cullenia excelsa. Effective area 32·5 sq. cm.

Specimen No. and direction of flow	Thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K cm.^{2}/day
1	2	3	4	5
I (7) .. .. Radial	0·215	0·017	0·039	0·0152
	0·215	0·034	0·101	0·0196
	0·215	0·068	0·18	0·0175
	0·215	0·136	0·346	0·0168
				Mean = 0·0173

(*contd.*)

TABLE VII—(*concld.*)

Specimen No. and direction of flow	Thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K $cm.^2$/day
1	2	3	4	5
II (2) .. .. Radial	0·215	0·017	0·004	0·00156
	0·215	*0·034*	*0·027*	*0·00525*
	0·215	0·068	0·078	0·00759
	0·215	0·136	0·108	0·00525
				Mean = 0·00491
I (3) .. .. Tangential	0·205	0·017	0·0013	0·00048
	0·205	0·034	0·036	0·00668
	0·205	0·068	0·086	0·00798
	0·205	0·136	0·405	0·0188
				Mean = 0·00849
II (8) .. .. Tangential	0·205	0·017	0·00035	0·00013
	0·205	0·034	0·013	0·0024
	0·205	0·068	0·027	0·0025
	0·205	0·136	0·077	0·0036
				Mean = 0·00216

Arsenic pentoxide (*Arsenic acid*).—As can be seen from the results given in tables VIII and IX, Fick's law holds good irrespective of species and direction of flow. This is provably due to the fact that unlike copper sulphate and potassium dichromate this substance is not precipitated in wood. The high value of the diffusion coefficient may be due to the high acidity. Christensen's work showed increased diffusion of sodium chloride with decreasing pH. It would be interesting to study the diffusion of $H_3A^sO_4$; or $H_2N^aA^sO_4$ and $N_{a3}A^sO_4$ to see the influence of pH.

TABLE VIII

Diffusion of arsenic acid at 30° C

Effect of increasing concentration

Canarium strictum, axial flow

Effective area 36 sq. cm.

Specimen No. and thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K $cm.^2$/day
I (11) 1·28	0·038	0·433	0·409
	0·076	0·90	0·425
	0·114	1·327	0·414
			Mean = 0·416
II (9) 0·755	0·038	0·372	0·205
	0·076	0·752	0·208
	0·114	1·185	0·218
			Mean = 0·210

TABLE IX

Diffusion of arsenic acid at 30°C

Effect of increasing concentration gradient

Cullenia excelsa. Effective area 32·5 sq. cm.

Specimen No. and direction of flow	Thickness cm.	Concentration difference mols/litre	Quantity flowing millimols/day	K $cm.^2/day$
1	2	3	4	5
I (6) .. .. Radial	0·133	0·038	0·556	0·0599
	0·133	0·076	1·198	0·065
	0·133	0·114	1·94	0·070
				Mean = 0·065
II (7) .. .. Radial	0·124	0·038	0·656	0·066
	0·124	0·076	1·322	0·066
	0·124	0·114	2·117	0·071
				Mean = 0·068
I (5) .. .. Tangential	0·198	0·038	0·16	0·026
	0·198	0·076	0·31	0·025
	0·198	0·114	0·459	0·025
				Mean = 0·025
II (4) .. .. Tangential	0·204	0·038	0·098	0·016
	0·204	0·076	0·179	0·015
	0·204	0·114	0·286	0·016
				Mean = 0·016

Ascu.—Tables X and XI show the diffusion constants of the constituents of 4% and 8% Ascu through *Canarium* sp. (axial) and *Cullenia excelsa* (tangential and radial flow). The tendency of the constant to increase with the concentration can be noticed in the case of the ingredients copper sulphate and potassium dichromate, even though not to the same extent as with the pure chemicals. Another interesting point to note is that the diffusion constant for the three constituents is almost the same. Arranged in the order of increasing diffusion coefficients, the following order is found :—Potassium dichromate; copper sulphate ; arsenic acid.

TABLE X

Diffusion of 4% Ascu and 8% Ascu at 30°C

Canarium strictum, axial flow. Effective area 36 sq. cm.

Specimen No. and thickness cm.		I (9) 0·69		II (9) 0·76	
Concentration difference mols./litre. w.r.t.	$K_2Cr_2O_7$	0·068	0·136	0·068	0·136
	$CuSO_4$ $5H_2O$ ..	0·06	0·12	0·06	0·12
	As_2O_5 $2H_2O$ ..	0·019	0·038	0·019	0·038
Quantity flowing millimols/day	$K_2Cr_2O_7$	1·1	3·3	3·7	8·3
	$CuSO_4$ $5H_2O$ ..	0·97	2·9	3·5	7·9
	As_2O_5 $2H_2O$	0·31	0·72	1·3	2·5
K cm^2/day	$K_2Cr_2O_7$	0·31	0·47	1·15	1·29
	$CuSO_4$ $5H_2O$ ..	0·31	0·46	1·23	1·39
	As_2O_5 $2H_2O$	0·31	0·36	1·44	1·39

TABLE XI

Diffusion of 4% and 8% Ascu at 30°C

Cullenia excelsa. Effective area 32·5 sq. cm.

Specimen No. and direction of flow	Thickness cm.	Concentration difference mols/litre w.r.f.			Quantity flowing millimols/day			K cm.²/day		
		$K_2Cr_2O_7$	$CuSO_4$ $5H_2O$	As_2O_5 $2H_2O$	$K_2Cr_2O_7$	$CuSO_4$ $5H_2O$	As_2O_5 $2H_2O$	$K_2Cr_2O_7$	$CuSO_4$ $5H_2O$	As_2O_5 $2H_2O$
I (7) .. .. Radial	0·11 0·11	0·068 0·136	0·06 0·12	0·019 0·038	1·16 4·53	1·0 4·5	0·38 1·53	0·058 0·113	0·056 0·127	0·068 0·136
II (6) .. .. Radial	0·11 0·11	0·068 0·136	0·06 0·12	0·019 0·038	0·46 1·53	0·284 1·23	0·14 0·41	0·023 0·038	0·016 0·035	0·025 0·037
I (4) .. .. Tangential	0·202 0·202	0·068 0·136	0·06 0·12	0·019 0·038	0·0089 0·044	Nil Nil	Nil Nil	0·0008 0·002	Nil Nil	Nil Nil
II (5) .. .. Tangential	0·202 0·202	0·068 0·136	0·06 0·12	0·019 0·038	0·016 0·069	Nil 0·049	Nil Nil	0·0015 0·003	Nil 0·0025	Nil Nil

Mercuric chloride.—Using mercuric chloride and *Bombax malabaricum* the results shown in Table XII were obtained. Here again the results are erratic.

TABLE XII

Diffusion of mercuric chloride through

Bombax malabaricum at 30°C

Effect of increasing concentration

No. and direction of flow	Thickness cm.	Effective area sq. cm.	Concentration difference mols.	Quantity flowing millimols/day	K cm.²/day
1. Axial	1·28 1·28 1·28	32·5 32·5 32·5	0·012 0·024 0·048	0·141 0·278 0·91	0·463 0·456 0·747
2. Axial	1·288 1·288 1·288	32·5 32·5 32·5	0·012 0·024 0·048	0·187 0·508 2·82	0·618 0·839 2·33
3. Tangential ..	0·324 0·324 0·324	36·0 36·0 36·0	0·012 0·024 0·048	0·106 0·230 0·51	0·0795 0·0863 0·096
4. Tangential .	0·354 0·354 0·354	36·0 36·0 36·0	0·012 0·024 0·048	0·077 0·185 0·572	0·0631 0·0758 0·117
5. Radial ..	0·356 0·356 0·356	36·0 36·0 36·0	0·012 0·024 0·048	0·1 0·264 0·575	0·0824 0·109 0·118
6. Radial .. .	0·32 0·32 0·32	36·0 36·0 36·0	0·012 0·024 0·048	0·146 0·405 0·762	0·108 0·150 0·141

Sodium flouride and boric acid.—The results obtained with sodium flouride and boric acid and a few species are given in Tables XIII and XIV. Generally sodium flouride diffuses better than boric acid.

TABLE XIII

Diffusion of sodium flouride

Concentration difference one mole.

Effective area = 40·32 sq. cm.

Species	Direction of flow	Thickness cm.	Temperature °C	K × 10^3 cm.^{2}/day
1	2	3	4	5
Boswellia serrata (heartwood) ..	T	0·16	34	0·23
,, ..	T	0·16	29	4·60
,, (Sap) ..	A	0·635	27	648
,, ..	A	0·635	27	797
,, ..	R	0·16	27	67
,, ..	R	0·16	27	69·6
,, ..	T	0·16	27	126
,, ..	T	0·16	27	161
Canarium strictum ..	A	1·27	30	171
,, ..	A	1·27	30	137
,, ..	T	0·635	30	2·44
,, ..	T	0·635	30	4·64
,, ..	R	0·635	30	6·35
,, ..	R	0·635	30	2·2
Vateria indica ..	A	1·27	30	101·4
,, ..	A	1·27	30	78·1
,, ..	T	0·16	30	0·62
,, ..	T	0·16	30	1·6
,, ..	R	0·16	30	1·78
,, ..	R	0·16	30	1·23

TABLE XIV

Diffusion of boric acid

Concentration difference—one mol.

Effective area 40·32 sq. cm.

Species	Direction of flow	Thickness cm.	Temperature °C	K × 10^3 cm.^{2}/day
Adina cordifolia ..	T	0·32	34·4	3·2
	T	0·16	35	18·8
Boswellia serrata (heartwood) ..	T	1·27	33	..
	T	0·32	33	0·91
	T	0·16	34	1·15
	T	0·16	29	0·91
Boswellia serrata (sapwood) ..	A	0·635	27	319
	A	0·635	27	621
	T	0·16	27	50·9
	T	0·16	27	49·8
	R	0·16	27	40·2
	R	0·16	27	26
Shorea robusta (sapwood)	T	0·16	35	18·8

(*contd.*)

TABLE XIV—(*concld.*)

Species	Direction of flow	Thickness cm.	Temperature °C	K × 10³ cm.²/day
Canarium strictum ..	A	1·27	30	24·4
	A	1·27	30	73·2
	R	0·635	30	2·44
	R	0·635	30	4·88
	T	0·635	30	3·66
	T	0·635	30	2·44
Vateria indica ..	A	1·27	30	29·3
	A	1·27	30	112·3
	T	0·16	30	0·37
	T	0·16	30	0·55
	R	0·16	30	0·98

Influence of temperature.—Two *Canarium* specimens (axial) and two *Cullenia excelsa* specimens (radial) were investigated at three different temperatures with 3% copper sulphate solutions. The results are given in Table XV. As is to be expected, the diffusion constant increases with temperature, the increase being greater with *Cullenia* specimens than with *Canarium* specimens. The temperature coefficients for 10°C rise are given in the same table. Christensen found a temperature coefficient of 1·38 for 10°C for sodium chloride and *Eucalyptus* which was constant between 70°F and 150°F.

In the present tests there is a slight decrease in the temperature coefficient with rise in temperature, which may be due to the fact that any reaction of the constituents of wood with copper sulphate is likely to be more, the higher the temperature.

TABLE XV

Diffusion of copper sulphate

Effect of temperature. Effective area 32·5 sq. cm.

Canarium strictum. Concentration difference 0·12 mols./litre

Specimen No. and direction of flow	Thickness cm.	Temperature °C	Quantity flowing millimols/day	K cm.²/day	Temperature coefficient
I (9) .. .. Axial	0·65	20	1·96	0·327	1·19
	0·65	30	2·33	0·388	
	0·65	40	2·63	0·438	1·13
					Mean = 1·16
II (9) .. .. Axial	0·70	20	0·99	0·176	1·22
	0·70	30	1·2	0·214	
	0·70	40	1·39	0·248	1·16
					Mean = 1·19
I (8) .. .. Tangential	0·21	20	0·152	0·0082	1·39
	0·21	30	0·212	0·0114	
	0·21	40	0·265	0·0143	1·25
					Mean = 1·32
I (8) .. .. Tangential	0·19	20	0·192	0·0094	1·28
	0·19	30	0·250	0·012	
	0·19	40	0·303	0·015	1·25
					Mean = 1·27

Influence of direction of flow.—The species investigated being hardwoods the longitudinal permeability, as is to be expected, is much more then that across the grain.

Copper sulphate diffuses through *Canarium* in the axial direction several hundred times as rapidly as in the direction across the grain. The radial permeability is higher than the tangential. Christensen found the radial diffusion to be 2 to 4 times the tangential for some Australian species. With *Cullenia excelsa* the radial permeability is 5–10 times the tangential permeability for potassium dichromate and 3–4 times for arsenic acid.

Influence of position in the tree.—In contrast to Christensen, who believes that there is no difference between heartwood and sapwood, our results indicate that specimens near or in the heartwood are less permeable than those running into the sapwood. For example, the diffusion of copper sulphate in the axial direction is ten times more in the sapwood than in the heartwood. In the radial and tangential directions also the specimens nearer the heart are more resistant. Similar behaviour is noticeable with potassium dichromate and arsenic acid.

Influence of species.—The results already given indicate that generally timbers which are easier to treat with fluids show higher diffusion constants. But at the same time (*vide* Table XIV) refractory timbers like *salai* and *Vateria indica* can be treated by diffusion, even though slowly.

Comparison with the results of other investigators.—As remarked earlier, apart from the work of Christensen very little work has been done on the subject. The present results point to the extreme complexity of the problem. While with substances like sodium chloride and arsenic acid, which do not react with the constituents of wood, it is easy to predict the depth of diffusion under definite conditions, it will not be so with various wood preservatives and other chemicals, which undergo chemical transformation in wood. The study of various individual chemicals and mixtures of chemicals should help in the selection of chemicals for diffusion treatments. Work on various organic molecules, resin forming substances, etc., is in progress in this laboratory.

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FOREST UTILIZATION AND TREE PLANTING

(Copy of a Radio talk delivered by Sri J. M. Lobo Prabhu, I.C.S., Secretary to Government, Development Department, Madras, on the 7th of July, 1951 at the All-India Radio Station, Madras)

Forests have a lyrical quality which has always appealed to human imagination. They are the scenes of the earliest stories of mankind. The Vedas, like the Nordic, Gallic, epics, breathe the magic of the forests. Shakespeare uses them as the background for his more beautiful plays. In our own time Tagore seems to have been dominated by the mystery and enchantment of forests. Many countries have made a cult of trees. The Japanese not only preserve their forests but introduce miniature trees in their gardens to create the verisimilitude of vast landscapes, in a small space. They have full grown trees decades of years old dwarfed to one hundredth of their size, to be kept in pots inside the houses. To the Germans, forests constitute the best idea of a holiday. In Berlin, vast and deep forests take away the severity of city's modern outlines.

If you think of it, there is, in all of us, perhaps for atavistic reasons, an invincible yearning for forests. Deep down we thrill at the green sweep which meets, our eyes at the mysterious luxuriance which we pass or penetrate. In the early light of the morning, the forests proclaim the birth of day, in the fading light of the evening they strike the appropriate note of parting. For their effect on the mind, as a garment of the lord, as a ladder to the infinite, sages have chosen forests for their retirement. In a world, therefore, of departing values, forests remain as one of the few treasures of our existence.

But what have we been doing with them ? What is called progress seems to be only cutting down of trees. In the Ramayana the Deccan Plateau and the now arid Ceded districts are described as Dandaka Vana, an impenetrable mass of forests. The Indus valley, now largely a desert, opposed the armies of Alexander, as a trackless forest. Before our eyes, since the war, trees are cut everywhere, and even the landscape of the Nilgiris, one of the finest in the world has been reduced to a patchwork of potatoes and mud.

It will be pleaded that the need of food is greater and that forests are a luxury which must make way for urgent necessities of a growing population. This argument overlooks the utility of forests in the balance of nature. The rapid denudation of tree growth from hill-sides and cultivable plains has led to devasting floods, erosion of soil, progressive diminution of rainfall and general deterioration of climatic conditions. The resulting shortage of fuel is compelling the cultivator to divert his farm yard manure from his field to his hearth, resulting in progressive impoverishment of the soil. To take the instance of the Nilgiris alone, the indiscriminate clearing of privately owned eucalyptus plantations of nearly 20,000 acres has resulted in an erosion of 100 to 150 tons of soil per acre, which not only threatens the fertility of the land involved, but of the vaster areas of land in the plains. This happens because the rivers are being silted up, the Cauvery in Tanjore having risen 2 or 3 feet since 1934, while the Mettur and Pykara reservoirs on which so much irrigation is built have risen much more. The mystery of the unbroken run of monsoon failures may also lie in the hill-sides bared of the foliage which attracts the clouds. Food and Forests are, therefore, not competitive, and forests cannot be reduced, without depriving fields of their water-supply and manure, and depriving cattle of their grazing and fodder.

In this context, the position of forests in the Madras State, may be surveyed. The area under Forests in the Madras State is about 18,000 square miles roughly 16% of the State.

The west more than the east of the State is heavily wooded, generally speaking the higher altitudes being the sanctuaries of the retreating trees. 15,000 square miles of forest belong to Government, the exploitation of which is carefully regulated by working plans related to the life and nature of the trees. According to these plans trees may be clear felled, the land being then replanted, selection felled, natural regeneration filling up the vacancies; or coppiced, growth from the stump supplying the regeneration. In 1949–50, the area clear felled was 3,809 acres selection felled 18,128 acres and coppiced 43,856 acres. While regeneration takes place field crops can be grown under the system known as *Kumri* of which the extent in 1949–50 was 901 acres.

The produce of forests is varied. In 1949–50 wood and charcoal of the value of 92 lakhs, sandalwood of 28 lakhs, bamboo of 16 lakhs and minor forest products of 11 lakhs were sold. Of the wood about 15 lakhs worth was timber, both hard and soft in proportion of two to one. Of the minor forest products, wattle bark for tanning leather, canes for furniture, nux vomica for alkaloids, myrabolam, soapnut, lac, tamarind, honey, wax may be mentioned. A Committee has reported the quantities of such products available in the State and Government are now actively considering plans for their utilization. Experts are also being secured for preparing plans and plants.

The life which forests support is enormous. Nearly one seventh of our cattle population is allowed to graze in Government forests. Wild life includes elephants, tigers, panthers, bears, deer, monkeys. The last named, monkeys have been migrating to inhabited areas just because the forests cannot support them. The problem created is one for which we can see no solution. Otherwise wild-life depends on a natural balance the tiger for instance keeping down the numbers of deer, which would otherwise follow the monkeys to cultivated areas. In the Madras State, we have a game sanctuary at Mudumalai which enables the study of wild-life apart from preserving an untouched patch of nature.

The positive policy of the Forest Department is to replant. Among the more interesting afforestation schemes are those for teak, 1,600 acres each year, casuarina for which a target of 150,000 acres has been fixed, wattle for tanning, cinchona for quinine, softwoods for match and plywoods, pyrethrum for insecticides.

A difficult and expensive kind of afforestation is necessary for eroded areas. Both the Forest and Agricultural Departments are carrying on experiments for finding the cheapest methods. Some encouraging work has been done in the Nilgiris. Soil Erosion Boards in the Nilgiris and for the State have been brought into existence. Government are also taking powers to prohibit the cutting of trees in private estates where this is necessary to protect the soil. They are also legislating for the creation of a National Park for the Wenlock Downs in the Nilgiris.

The task of afforestation cannot end with what Government are doing. It has to be extended to every part of the country because only when the land becomes green with trees will the soil be moist and the air cool. This is the purpose of the Tree Planting Week we are celebrating, of to-day's festival, *Vana Mahotsava*. For the past three years the festival has been held on a national scale. Last year, we planted nearly 83 lakhs of trees of which 17 lakhs were fruit trees. This year a target of 50 lakhs is set with 500 trees per village. Tree planting committees have been organized at different levels. Prizes have been created for records which individuals, districts or institutions will set. Meetings are being held to create interest in a subject the importance of which is overlooked.

The question to be asked is, if enough is being done. The plan for planting 50 lakhs of trees would imply even at the rate of one tree per person which is not true, that only one tenth

of our population will share in the task. Some one has said that to plant a tree is to bind in gratitude at least four generations, who will have shade from the Sun, rain from the skies, fruits, flowers and fuel from the earth. How can we make an increasing section of the population conscious of this opportunity for immortality ? One suggestion is that the whole State should be divided into small circles each with a Tree lovers committee, which will train children to track every individual with the question if he has planted his tree. At the same time, all the land available in private and public properties may be surveyed by the Committee for making out the places to be planted. Such Committees can work only on goodwill with entreaties, songs, meetings to create consciousness of the task of making India a green and pleasant land.

Planting alone is not enough ; aftercare is most important. There is watering to be done for short periods, and there is watch and ward to be maintained against cattle and goats. Until trees are more numerous and foliage plentiful, animals will attack growing plants. A grille with strips of iron is best, but even some cages of sticks and thorns can do, though these have to be watched against being stolen for fuel. It is not easy, therefore, to raise trees, for which reason, the country has to be roused to the task by every means possible. In this task, those who know and understand have to teach and persuade those who do not. Love of tree has to become almost a religion, if the encroaching desert is to be repelled, and the green and pleasant outline restored to our landscape. With trees, life began on the earth, with more of them, we can give our civilization the appropriate contour and colour, the proper balance between nature and progress, the true contract between utility and beauty. To the extent we worship trees, in the spirit, if not the manner of our ancestors, Heaven will not pass away from the earth.

A STUDY OF THE SOUTH INDIAN TAN-WATTLES

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SUMMARY

The cessation of trade relations with South Africa in 1947–48 and consequent stoppage of wattle imports (40,000 tons annually) from that country have led to an unprecedented demand on the home-grown wattles which had attracted little attention in the past. The elaborate technique adopted in recent plantations, raised on the grassy downs in the Nilgiris (Ootacamund) and Upper Palnis (Kodaikanal) where about 20,000 acres are available for the cultivation of wattle, requires considerable modification in the light of large scale failures. A detailed study of the various adverse factors inhibiting the growth of wattle revealed that protection against frost and cold desiccating winds has not had the attention it deserves. The invasion of wattle under the shelter provided by the Eucalyptus plantations and its vigorous development in the gaps where they exist in the overwood, suggests the following technique :—

(*i*) Secure shelter for wattle, 3 years in advance, against—

(a) Strong cold winds by raising Eucalyptus all round an area 5 rows 6 feet apart,

and, (b) frost by planting Eucalyptus 40 feet apart.

(*ii*) The existing practice of scrapping of 4 feet wide strips 5 feet apart along the contours (Kodaikanal) involving prohibitive costs be replaced by seed beds 2 feet diameter, 9 inches deep and 6 feet apart.

(*iii*) Thin to 12 feet espacement at the end of 3 years.

2. The vigorous growth of wattle on abandoned potato and pyrethrum fields renders it practically immune to frost and suggests the cultivation of potatoes as a means of raising wattl in localities where there is demand for land, such as Nilgiris. Managed on a rotation of 10 years, each unit of area will be for a year under potatoes and for 9 years under wattle, which will more than recoup the loss of soil and its fertility. A crop or two of potatoes will not only pay for the subsequent plantation of wattle but also add to our food supply—a fact not to be lost sight of in the context of the existing food situation. While shelter against frost is not indicated, that against wind would be indispensable in most localities.

3. Possibilities of wattle cultivation exist in Travancore-Cochin where about 20,000 acres could easily be made available. In the higher Himalayan latitudes a lower altitude is indicated, where *chir* could replace Eucalyptus to provide shelter.

Among the bewildering varieties of the vegetable tans available in India, the Australian wattles are the most prized for their high percentage of tannin contents. Of the many species of wattles, only two are acceptable to the trade, viz., *Acacia mollissima* and *Accacia decurrens*, the tannin contents of whose barks vary from 30 to 35 per cent, against about 15 to 18 per cent of the indigenous *Acacia arabica* (*babul*) and *Cassia auriculata* (*avaram*). Of the two wattles, the *decurrens* variety is less popular with the tanners for the unacceptable colour it imparts to leather. Until recently, India imported from South Africa about 40,000 tons of wattle bark annually. With the cessation of trade relations with South Africa in 1947–48, wattle imports came to a stand still, resulting in an almost unlimited demand for home-grown wattles.

I. SCOPE FOR CULTIVATION OF WATTLES

2. The Nilgiris, where wattles were introduced in the middle of the nineteenth century (1843), as a source of cheap supply of fast-grown fuel for the army stationed at Wellington, and later, as shade trees in tea-estates, have assumed in recent years special importance for the opportunities they provide for the extension of wattle cultivation. In the Upper Palnis (Kodaikanal), where wattle was introduced in the eighties of the last century, and in the Kannan Devan hills (Travancore), one may expect to find large areas suitable for raising wattle to make our country self-sufficient in respect of this species. In the Himalayas (e.g., Naini Tal, Ranikhet) one comes up against odd specimens of wattles introduced as ornamental trees. The possibility of developing commercial wattle plantations in this region deserves to be explored in view of the large demand for wattle barks for the tanning industry. The pre-war prices of imported wattle bark ranged from Rs. 120 to 150 per ton delivered at the tanneries in neatly packed bales. The prices of the South Indian wattle bark have touched Rs. 700 per ton—a circumstance which has attracted the attention both of the State and of private growers. These inflated prices are, however, apt to queer the pitch for establishing well-planned plantations of wattle on sound economic lines. The possibility of the resumption of trade relations with South Africa, as well as the recent wattle imports from Kenya at a little over half the Indian price should not be lost sight of while planning for the future.

3. In South India, vast opportunities exist for the extension of wattle. The grassy downs in the Nilgiris and Kodaikanal could easily find an area of 5,000 and 15,000 acres respectively for the purpose. The Kannan Devan hills (Travancore) would account for at least another 20,000 acres (Devikulam and Peermade *taluqs*). It is difficult to give an idea of the possibilities of growing wattle in the Himalayas at this stage.

II. EDAPHIC AND CLIMATIC REQUIREMENTS

4. While wattles would flourish on a variety of soils, those derived from the rocks obtaining in the Nilgiris and Upper Palnis seem to be particularly suitable. Wattles grow best in well-drained and fairly deep loams occurring at elevations above 5,000 ft. in the South. A lower elevation where snowfall and frost are not serious factors, would appear to be indicated in the higher Himalayan latitudes. Wattles prefer moderate climate, exhibiting great intolerance to the extremes both of heat and cold. The optimum range of temperature would appear to be 40 to 85 degrees F ; and that of rainfall 35 to 75 inches distributed well over the cold weather and the monsoon months. A somewhat higher rainfall would constitute no major obstacle, as Ceylon wattle localities suggest.

III. SILVICULTURAL FEATURES

5. Although a light demander, wattle can tolerate considerable shade and seems to respond to the protection afforded by high Eucalyptus trees under which it establishes itself naturally in the second storey. While it manages to survive in a whippy stage under dense overwood, it exhibits excellent development in gaps where Eucalyptus trees are spaced 40 to 50 feet apart. Wattle is exceedingly frost tender, and plants up to 24 inches in height have to be protected by specially designed bracken fern capes for one, and not unoften for, two winters. Occasionally, plants up to 10 feet in height might be killed right back to the ground in the case of a particularly severe frost. Not unlike other species, wattles prefer well-worked soils, and show a particular predilection for abandoned cultivation of potatoes and pyrethrum. Profuse root-sucker and coppice regeneration is not uncommon in wattle areas and natural regeneration from seed seems easy to obtain under shelter. The seed is light (*mollissima*

1,550 ; *decurrens* 2,200 per ounce) and germinates well after being pre-treated. The treatment consists of immersing the seed in boiling water and allowing it to cool off for about 12 hours and washing it clean off the mucillage. The seed is then dried and stored in shade. On no account is the seed to be boiled in water. The germination and plant per cent of treated seed is about 50 and 15 respectively. About a pound of seed would suffice for a nursery bed 40 feet by 4 feet. The germination starts in a week and extends over a month. The seedling beds require frost cover. Treated seed can be stored for a year without loss of viability.

IV. THE EXISTING PLANTING TECHNIQUE

6. The elaborate planting technique developed in the Nilgiris and Kodaikanal merits careful examination if the South Indian wattles are to hold their own against foreign competition. The inaccessible nature of the localities in which wattles are grown and the lack of good communications, impose an additional strain on the economics of this species. The planting techniques now adopted by the Madras Forest Department are indicated below :—

(i) *Nilgiris.*—Entire transplants (6 to 9 months old mossed seedlings) are put out in pits (1 ft. cube) at the break of rains (June 15 to July 15), 11 feet apart. An Eucalyptus wind-belt of 5 rows, 6 ft. apart all round, and wind-breaks of 5 rows 11 ft. apart, alternating with 50 rows of wattle have been prescribed at Mukerti, Nilgiris. The cost of formation amounts to about Rs. 40 per acre.

(ii) *Kodaikanal.*—Grass is scraped in 4 ft. wide strips, 5 ft. apart, along the contour. Seed is sown in April–May in two rows, in 1 ft. cubes, 9 ft. apart, made in scraped strips. Germination is followed by two weedings and strip cleanings, one in August ; the other in October. Bracken fern capes are provided as frost cover in the following winter. This protection is afforded again in the second winter to plants below 24 inches which constitute 50 per cent of the crop. The cost of the formation and establishment amounts to about Rs. 60 per acre.

V. SOUTH AFRICAN PRACTICE

7. In South Africa, in virgin grasslands where wattle is established for the first time, ploughing and disc-harrowing is resorted to. Super phosphates are also used at (250 lb. per acre) in some areas. Grasses are *not* burnt but ploughed in, to improve the physical texture and the organic contents of the soil. In the second rotation simple hoeing exposing the mineral soil along the seed line suffices.

VI. REVIEW OF RESULTS OBTAINED

8. By far the best plantations that I have seen are those which were raised in the past on abandoned potato lands (*tuckle*) and more recently on abandoned pyrethrum fields around Berijam lake (Kodaikanal) and Andy's corner (Ooty). Comparatively recent plantations have, to date, not yielded encouraging results. The 1950-transplants, put out over an area of about 550 acres at the Mukerti (Nilgiris) downs have failed for all intents and purposes, the survival per cent not being more than 20. Around Kodaikanal, the total area of grasslands attempted during the last 10 years (with the exception of 1944 when no work was done) amounts to about 2,750 acres. The earlier plantations (up to 1947) exhibit a stocking varying from about 50 per cent to complete blanks. In the younger plantations it is too early to estimate the ultimate stocking ; but if an average figure is to be hazarded it will not exceed 25 per cent. The general growth of plants is poor. By far the best results

have been obtained in localities protected from cold winds (Gundar 1949-area) and on well-worked soils.

VII. FACTORS INHIBITING GROWTH OF WATTLE

9. An analysis of the causes which have conspired to hold back the progress of wattle plantations, both in the Nigiris and around Kodaikanal reveals the operation of a hitherto unsuspected factor which deserves special emphasis. True, at Mukerti (Nilgiris) the mossed transplants used were small, but surely this could not account for such a large scale failure. For, the smallest transplant is bigger than a seedling raised on the spot from seed. Around Kodaikanal, fire has been responsible for wiping out only a small area not exceeding 100 acres under wattle (extending from mile 10/2 to mile 12/6). This, by no means explains away the large scale failures which characterize these plantations, despite the exceedingly elaborate soil working, weeding, provision of frost covers, and considerable expense.

10. Looking at one of the plantations (1946 area, Kodaikanal) it was discovered accidently that the vast bulk of the plants was killed back to the ground by frost, as the split bark on the stems up to 10 feet high still lying on the ground obviously suggested. It does not seem to have been sufficiently realized that the localities set apart for raising wattle in this region are particularly exposed to the severe cold winds causing excessive desiccation and not unoften the death of young seedlings. In addition, what seems to have escaped attention is the occurrence of sharp frosts which might be so severe as to kill even 5-year old plants right back to the ground. The South African practice confines the raising of wattle to what they call the 'mist-belt' at altitudes varying from 2,000 to 4,500 feet. Frosty localities and higher elevations liable to strong cold winds and snow damage are avoided. Grassy downs set apart for the cultivation of wattle both in the Nilgiris and the Upper Palnis (around Kodaikanal) are peculiarly susceptible to cold winds and sharp frosts. The fact that these areas have supported no tree-growth within human memory, points to the difficulties of the task ahead.

VIII. TOLERANCE TO SHADE

11. Going over some of the Eucalyptus plantations, one is struck by the invasion of wattle which occupies the second storey to the exclusion of everything else. At Kodaikanal, a plantation of *Eucalyptus globulus* near the Observatory provides an illustration par excellence of this phenomenon. In the larger gaps, where Eucalyptus is accidentally spaced about 40 feet apart, an excellent crop of wattle has come to establish itself. While the bulk of the crop under a close upper canopy is thin and whippy, occasional stems have shot up to the height of 40 feet where there are gaps in the overwood. This area points to the provision of shelter being far more important than the elaborate soil working, weeding and frost covers. In these Eucalyptus areas, wattle seed blown across from the roadside wattle-belt seems to have discovered for itself conditions favourable for germination and establishment. The plants are ready to shoot ahead with the provision of overhead light. The surprise is not that these dense wattle thickets under heavy Eucalyptus overwood are bent, crooked and whippy, but is that they have managed to subsist at all without overhead light, without growing space.

IX. SUGGESTIONS FOR IMPROVEMENT OF THE EXISTING TECHNIQUE

12. Taking a cue from the invasion of wattle under Eucalyptus, our planting technique requires radical departure from the existing practice. The ease with which wattle establishes itself under light overwood, points to the planting of Eucalyptus 40 feet apart, 3 years in

advance of the introduction of wattle. Eucalyptus itself might require in some localities protection against frost for the first year at least, but it is not half so frost tender as wattle. It is also necessary to raise a Eucalyptus wind-belt of 5 rows, 6 feet apart along the boundaries of the area with intermediate belts as adopted at Mukerti (Nilgiris). Once the wind belts and Eucalyptus standards have been established, it will be easy to introduce wattle without the need of having to resort to the elaborate soil preparation as adopted at present at Kodaikanal. Attention to the wasteful method of the scraping of 4 feet wide strips along the contours, has already been drawn by Shri N. D. Sahni, I.F.S., Conservator of Forests in his Inspection Report of June, 1950. I am in complete agreement with Shri Sahni's recommendation regarding the discarding of these strips. Once Eucalyptus has been established, all that would perhaps be necessary would be to hoe 2 feet diameter patches about 9 inches deep, 6 feet apart and sow seed. A closer espacement is indicated in the first formation of wattle plantations on virgin grasslands, to kill the grass, provide against failures and secure a better choice of stems for the future crop. A thinning would be indicated at the end of 3 years when the plants may be spaced 12 feet apart. In the second rotation the state of natural regeneration would determine the magnitude of artificial planting.

13. In the Himalayas, *chir* or khasi pine shelterwood might well replace Eucalyptus in wattle plantations (Krishnaswamy). As a matter of fact wattle has successfully established itself under *Pinus insignis* at Kodaikanal. At lower elevations (c. 4,000′) along the road to Kodaikanal (Mile 18), some of the gall nut areas with less vigorous climatic conditions present possibilities for the introduction of wattle well worth exploration.

X. CULTIVATION OF WATTLE AROUND KODAIKANAL

14. The answer to the wattle problem in this region, paradoxical as it may sound, would seem to be to grow Eucalyptus to raise wattle under. The existing Eucalyptus plantations amounting to about 160 acres around Kodaikanal, provide almost ready-made conditions for the introduction of wattle where it does not exist already. A spacing of 40 feet should be secured among Eucalyptus in the upper storey, and the existing stock of wattle should be thinned to a spacing of 12 feet. In blanks, wattle may be sown as indicated above. This would virtually convert Eucalyptus into wattle plantations. Fuel requirements of Kodaikanal can be met from rapidly deteriorating pine areas and later on from wattle plantations themselves. In addition, the formation of large-scale wattle plantations on grasslands should continue, as heretofore, with the modification that the Eucalyptus shelter should be established well in advance. The management of Eucalyptus standards and wind-belts need not detain us at present. As they are intended in the main for protection, a physical rather an economic rotation is indicated for them. The standards may, however, be managed on a rotation of 43 years coinciding with the felling of the 4th crop of wattle. The ensuing coppice shoots would rapidly replace them and 3-year advance planting would no longer be necessary.

XI. RAISING WATTLE IN THE NILGIRIS

15. In the Nilgiris, where the demand for land is almost unlimited, by far the best and the most economical method of raising wattle would be to resort to the advance cultivation of potatoes to ensure efficient soil working and elimination of grasses. Wattle should be sown after two potato crops have been raised. The land need not be under potatoes for more than a year, for it exhausts the fertility of the soil. In a thousand acre unit, on a 10-year rotation, 100 acres could be continuously kept under potatoes. Each unit of a hundred acres will remain for a year under potatoes, and for 9 years under wattle. The effective rotation of wattle will thus be 9 years only. As has been pointed out already, wattle raised on abandoned potato and pyrethrum cultivation (*tuckle*) has yielded the best results. Not only

does the cultivation of potato ensures the success of raising wattle subsequently, it also provides the wherewithal to meet the expenditure to be incurred. At current planting costs in the Nilgiris, the establishment of a thousand acres of wattle plantations would cost about Rs. 40,000. With advance potato cultivation, all this money would be found by the potato crop on a 100-acre unit kept rotating all over the area. The terms of agreement with the potato cultivating concern should provide for a substantial cash security to be forfeited in the event of infringement of any of the prescribed conditions. As this venture involves investment of large capital, only large corporations should be considered. While the lessee should be called upon to raise an Eucalyptus surround of 5 rows, 6 feet apart as a protection against wind all round the annual unit of area placed under potatoes, the subsequent raising of wattle should be the concern of the Forest Department. So rapid is the establishment of wattle on abandoned potato fields that the advance planting of Eucalyptus 40 feet apart as a protection against frost is not indicated. In localities where sharp frosts occur bracken fern capes and mulching (Ranganathan) may be resorted to. The loss of soil from carefully terraced potato fields (which should be a condition of the agreement) is likely to be more than compensated by the subsequent occupation of the ground by a leguminous species like wattle for a period of 9 years. If the terracing of fields can be rigidly enforced with properly graded trenches, there is no reason why the fertility built in the soil by wattle, should not again be exploited after the end of the first rotation and the plantation of wattle formed *de novo* from seed without incurring any expenditure. It might be mentioned here that potato cultivation during recent years has come to be recognized as a standard practice in the regeneration of khasi pine on the Shillong plateau. In the context of the existing food situation, this technique deserves special notice.

XI. ACKNOWLEDGMENTS

16. It only remains to be added that these conclusions have been arrived at after a careful analysis of the various factors inhibiting the growth of wattle in the South, in collaboration with Shri V. S. Kuppuswamy, Conservator of Forests and Shri C. A. R. Bhadran, District Forest Officer, who accompanied me throughout my tour. I am also beholden to Shri K. N. Raghavan Nair for the silvicultural data he supplied, and to Messrs. M. Kesva Unni Nayar, Ranganathan and Krishnaswamy for many useful suggestions.

OCIMUM KILIMANJARICUM IN MYSORE

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The importance of Camphor in national economy, both in peace and in war, is well-known. India is entirely dependent on imports for her camphor. Indigenous sources of production are, therefore, of great importance. In this context, *Ocimum kilimanjaricum* is a source of promise as pointed out by P. N. Deogun[1]; more recently D. J. Reveiro gives an account of the species in Bombay[2]. The present paper summarizes the results of experiments with *Ocimum kilimanjaricum* in Mysore over a period of two years.

25 gms. of seeds which were obtained from the Forest Research Institute, Dehra Dun, were kindly donated to us in February 1949 by Shri S. G. Sastry who, as a result of his experience elsewhere, was not very optimistic about their viability. The seeds were divided into two batches. One batch, about 12 gms. was sown in raised seed beds, 22 beds 2′ by 2′. Of the remaining 12·5 gms. 30 seeds were sown (on 23–2–49) in two pots—15 in each. The rest of the seeds, about 12 gms., were kept in reserve. The pots and seed beds were carefully watered with cans fitted with rose-spray. The first seedling appeared in a pot after 5 days and in the bed after the 10th day. Germination was, however, very poor as we obtained only 17 seedlings in all from 12·5 gms. of seeds. At the end of the first month, the seedlings had 6–8 leaves. At the end of 4 months, we transplanted, into 1 foot cube pits, 12 plants (28–6–49), 1 again on 28–7–49. The other 4 seedlings were casualties to red ants. Attempts to ward off such attack by placing the pot surrounded by water and dusting the base of the plant with pyrethrum powder proved ineffective. It is from this stock of 13 transplants that all our subsequent stock was raised and the several experiments conducted. And, on 23–2–51 two years after the experiment started, we had in the field some 15,000 plants and in stock about 500 lb. of herbage 1,500 gms. of seed and some 2,500 gms. of distillate.

NURSERY PRACTICE

We found it simplest to mix the seeds with light sand before sowing so as to procure even distribution. A likely pitfall to be avoided is too deep sowing. We found the most satisfactory germination with fresh seeds. Pretreatment of seeds by soaking in (*a*) water (*b*) cocoanut water and (*c*) Horse's urine, in each case, for 18 hours, gave results in favour of treatment (*b*). This, however, has to be statistically confirmed.

BROADCAST SOWING

A level plot of ground adjacant to the Laboratory, 165′ × 116′ was selected for the experiment. The land was ploughed (about 1 foot deep) by a light tractor and levelled with a harrow. The plot was divided into 4 equal sections. On 4–7–50, with a very light drizzle on, 140 gms. of seeds were mixed with light sand and sown broadcast over the area and as evenly as possible by an experienced nurseryman. Germination was extremely poor and by 25–8–50, there were only about 100 seedlings. These were removed for transplanting, the area then harrowed and 50 gms. of seeds were again sown broadcast. There was a sharp shower the same night. Germination was again poor and by 23–9–50, there were not more than about 25 seedlings. A third and final attempt was made on 23–9–50 by sowing broadcast

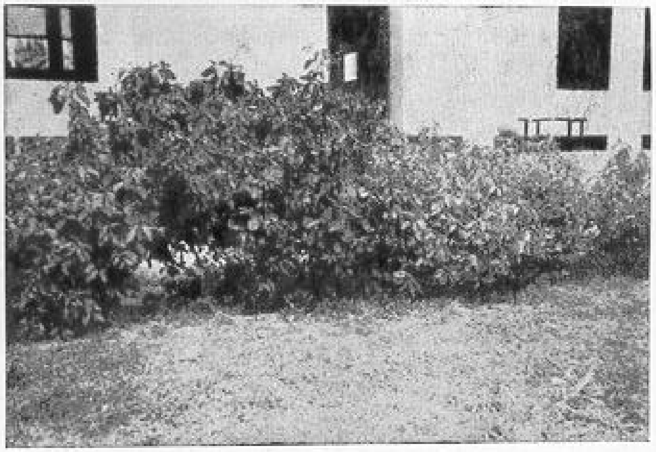

PHOTO 1

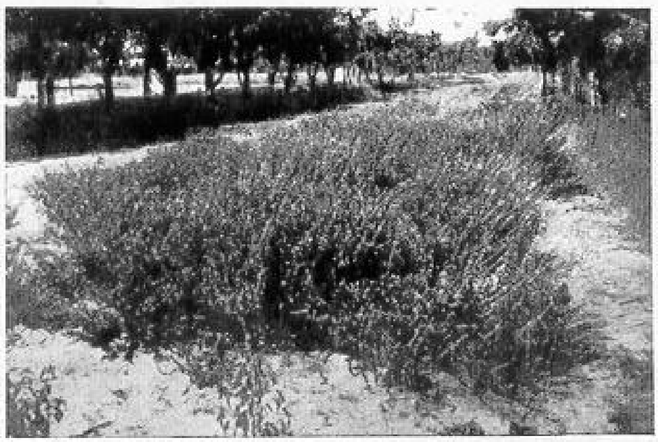

PHOTO 2

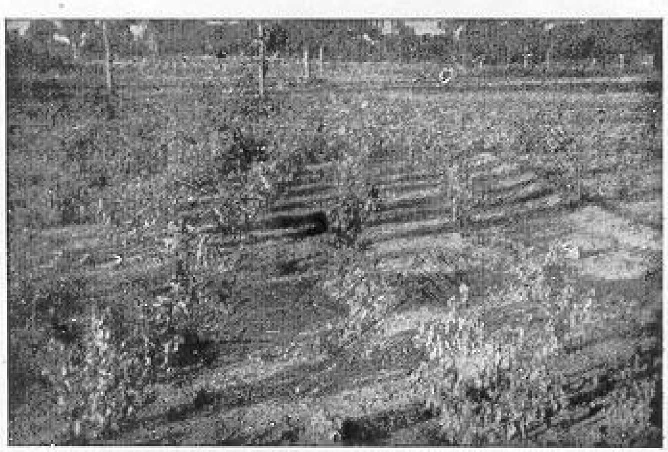

PHOTO 3

10 gms. of seed over a much smaller compact area of 20 feet by 20 feet. Germination once again was very disappointing. In these experiments, ants proved to be a menace avidly attacking the seeds.

PLANTS GROWN UNDER HORTICULTURAL CONDITIONS

10 plants exactly 4 months old from date of sowing were transplanted into two trenches (12′ by 3′ by 2′) originally intended to be flower beds. The trenches were filled with red earth, sand and well-rotted farmyard manure (3 : 2 : 1) and watered daily. The planting stock came from seeds sown on 4–7–49 and the date of transplanting was 3–10–49. They were a fine sight on 3–12–49 when they were about 4 to 4½ feet high and in bloom, the flower stalks being more than 9 inches long. The plants had put on a height of 5′–6″ to 6′–0″ by 7–3–50. They were pruned on the latter date. The green herbage weighed 21 lb. which, on air-drying, was reduced to 3·5 lbs. of leaves. The air-dry leaves, on steam distillation, did not, however, yield any oil ; presumably the crop was too young. One month after the first pruning, a second cut was made on 7–4–50, when 20 lbs. of herbage were again obtained. This latter also did not yield any distillate. Our experience in this plot was that leaves less than about 12 weeks old contain very little, if at all any oil. From 7–4–50, the ripe yellow leaves which fell as litter were collected separately. 89 gms. of this material (air-dry) on distillation in the Laboratory gave 2·62 gms. of camphor and oil, which amounts to 2·97 per cent on the air-dry material. A third cut was made on 3–7–50. These ten plants are now 21 months old from the date of sowing, have been cut 4 times for herbage and are now ripe for a fifth cut. The plants look healthy and vigorous at the time of reporting (April 1951). Photograph No. 1 taken at the beginning of October 1950 shows this group of plants 3 months after the third cut.

PLANTS GROWN UNDER IRRIGATION AND WITHOUT IRRIGATION

Fairly detailed records were kept for these two blocks as these were considered to be most nearly approximate to field conditions under which the crop was likely to be grown in the State. The two plots, plot 5 under irrigation and plot 9 without irrigation were neighbouring blocks so that the soil and climatic conditions are identical for both and are as follows :—

Height above sea-level	3,002 feet
Soil	pH 5.9

Analytical values :—

Organic matter	8·03
$Si\,O_2$	67·43
$Al_2\,O_3 + Fe_2\,O_3$	22·15
$Mn_2\,O_3$	0·50
$Ca\,O$	0·50 per cent

Rainfall and Temperature at Bangalore during 1949 and 1950

Month	1949 Rainfall in inches	1949 Temperature°C Maximum	1949 Temperature°C Minimum	1950 Rainfall in inches	1950 Temperature°C Maximum	1950 Temperature°C Minimum
January ..	0·00	31·1	14·2	0·00	27·2	14·2
February ..	0·31	29·4	15·9	0·08	29·4	17·2
March ..	0·00	32·8	19·2	0·00	31·9	19·7
April ..	1·57	33·4	21·4	0·10	34·2	21·3
May ..	1·86	31·9	21·2	3·94	33·4	21·7
June ..	3·71	28·9	29·5	2·49	28·5	19·4
July ..	13·79	26·9	19·2	3·81	26·6	18·9
August ..	6·52	26·9	19·2	5·21	27·5	19·2
September ..	4·03	26·2	18·9	4·18	26·6	18·5
October ..	6·70	26·6	18·3	7·14	26·6	18·1
November ..	3·83	26·2	16·1	7·04	25·8	16·4
December ..	0·00	25·8	13·8	0·03	25·7	14·7
TOTAL ..	42·32			34·02		

Plot No. 5. Irrigated :—

Dimension 225′ × 25′

Espacement 5′ × 2′·6″.

Nursery stock came from seeds sown on 4–7–49. 175 seedlings were transplanted in 1 foot cube pits on 8–9–49. The plants were irrigated daily by a system of shallow channels. On 30–3–50, maximal height of plants was 4′·6″ and average height of plants was 3′·6″. First harvest of herbage was made on 30–3–50. Photograph No. 2 taken at the beginning of October 1950 shows this group of plants 3 months after the second cut.

Green weight of herbage obtained in the first cut .. 54 lb.

Air-dry weight of herbage .. .. .. 18 lb.

Air-dry herbage was steam distilled. Distillation was complete in 2 hours and about 100 c.c. of crude distillate were obtained. On redistillation 29·5 gms. of camphor and 61·0 gms. of oil were obtained which (total distillate) works out to 1·09 per cent of the air-dry herbage.

The oil plus camphor was finally redistilled once again and had the following constants ; for purposes of comparison, the constants quoted by Guenther[4] are also given alongside.

	Mysore sample	Sample quoted by Guenther
Sp. Gravity at 90°/90°C ..	0·9436	0·964 at 15°/15°C
Optical rotation	+33° 66′ at 25°C	−1° 48′
Refractive Index of distillate 20°C ..	1·47545	1·4959
Acid number	0·55	3·7
Saponification number	3·64	3·7
Phenol content (Eugenol) ..	14 per cent	30 per cent
Solubility at 20°C	Insoluble in 70% alcohol. Soluble in 85% alcohol in all proportions.	Soluble in 3 volumes of 70% alcohol. Opalescent in 10 volumes.

N.B.—The specific gravity is determined at 90°C. This was to get a homogenous sample with the camphor in solution. To obviate the same difficulties the Refractive index was determined in the oil freed from crystalline camphor.

We may also add that Yongken and Hassan distilled the plant and obtained an oil with the following properties.

Specific gravity at 25°C ..	0·9225
Refractive index at 20°C ..	1·4752

This is also quoted by Guenther. The Camphor was identified and its purity established by its m.p. and its conversion to its oxime. The purified colourless crystals had the characteristic camphor odour and on ignition burnt complete without a residue.

A second harvest of herbage from the 175 plants was made on 3–7–50.

Air-dry weight of herbage	13·5 lb.
Weight of crude distillate	150 gms. approx.
Weight of Camphor and oil on redistillation	132 gms.

which works out to 2·2 per cent of the air-dry herbage.

A third harvest was made on 12–1–51 but the herbage was not separately handled and was mixed up with the harvest from other blocks for convenience in handling. It will be noticed that the interval between the second and third cut is about 6 months and not 3 as between the first and second cuts. The longer interval was due to the crop being conserved for seeds.

It may be added that after the harvest on 3–7–50, the twigs were carefully separated from the leaves. On steam distillation the twigs, did not yield even a drop of oil.

It has been our experience during every one of the distillations that the later fractions of the distillate are richer in Camphor—the greater part of the solid coming over with the final fraction.

Plot No. 9. Not Irrigated:—

Dimension 250′ × 155′

Espacement $2\frac{1}{2}' \times 2\frac{1}{2}'$.

Soil and climatic conditions were identical with those recorded above for Plot No. 5.

The crop in this block consisted of 3,557 plants made up as follows. 75 seedlings were obtained from seeds sown on 19–12–49 and were transplanted into 1 foot cube pits on

25–3–50. The remaining stock came from seeds sown on 20–3–50 and transplanted on different dates. The total stock was as follows :—

Date	Number of transplants put out
25–3–50	75
10–6–50	276
17–6–50	450
19–6–50	350
20–6–50	145
22–6–50	108
4–7–50	195
5–7–50	390
9–7–50	262
12–7–50	485
25–7–50	280
29–7–50	325
31–7–50	216

Total number of plants in the block 3,557.

Photograph No. 3 taken at the beginning of October 1950 shows this group of plants.

On 18–10–50 the maximal height of this group of plants was 3 feet and on this date, the first collection of herbage was made from 2,000 surviving plants.

Weight of air-dry herbage	50 lb.
Weight of air-dry leaves	35 lb.
Weight of air-dry twigs	14·5 lb.

The air-dry leaves were steam distilled in a copper still and the crude distillate was redistilled in glass apparatus when 303 gms. of oil and camphor were obtained. This works out to an yield of 2·24 per cent on the air-dry leaves.

On 10–1–51, a second harvest from the same plants yielded 57 lb. of air-dry leaves. We could, therefore, take it that 2,000 plants yield 92 lb. of air-dry leaves in the first year from the date of sowing under unirrigated conditions.

EXPERIMENTS UNDER FIELD CONDITIONS

These experiments were conducted at Mudugere about 42 miles from Bangalore on the Bangalore–Mysore road. The area is at an altitude of Co 2,900 feet above sea-level

and the rainfall recorded at Channapatna, about 4 miles from the plantation, is as follows :—

Rainfall at Channapatna during 1950[3]

Month	Rainfall in inches
January	0·00
February	0·30
March	0·00
April	0·00
May	2·41
June	4·90
July	1·89
August	11·18
September	1·46
October	11·12
November	3·83
December	0·00
TOTAL	37·09

The soil is a rich red loam with a pH of 5·9.

Broadcast sowing again failed in this area. 2 acres were ploughed twice, harrowed and 250 gms. of seed sown broadcast by an experienced fieldman, on 30–9–50. There were heavy showers in this area from 11–10–50 to 16–10–50 and although a few seedlings did appear here and there, it was noticed that by 25–10–50, the few tender seedlings had failed to survive in the dry hardened mass of the soil. Broadcast sowing was not successful.

7,000 seedlings (from seeds sown on 5–4–50) were transplanted in 1 foot cube pits during the four day period 27–6–1950 to 30–6–50. The espacement was not regular on account of these transplants being interplanted in a one year old crop of *Wrightia tinctoria* and *Melia dubia*. The plants were watered, once daily, by a system of shallow channels during the early stages.

At the end of 3 months from the date of transplanting the heights recorded were.

Maximum	4 feet
Minimum	$2\frac{1}{2}$ feet
Average	3 feet

On 18–10–50 (about $3\frac{1}{2}$ months after transplanting) the first crop was harvested in the course of 3 days and the air-dry leaves weighed 275 lb. This was distilled in a semi-commercial copper still with steam at a pressure of 80–90 lb., and during the course of 4 hours, some 5 litres of the crude distillate was collected. On redistillation in glass apparatus in the Laboratory, 2,520 gms. of the pure distillate were obtained. This is an yield of 2·04 per cent on the air-dry leaves. The mixture of oil and camphor was filtered through a Buchner and the solid camphor dried against porous porcelain. 860 gms. of pure camphor were thus obtained. The essential oil (in which some camphor was presumably still dissolved) weighed 1,660 gms. The latter on chilling for 48 hours at 8°C deposited a further 210 gms. of camphor. The total yield of camphor was thus 1,070 gms. and of oil 1,450 gms. It might be added that the distillation of the herbage calls for some attention on account of the crystalline

camphor tending to choke the condenser. This can be minimized, with some experience, by suitably adjusting the rate of in flow of steam from the boiler. Also during the refining of the distillate in an all-glass apparatus, we had to use extra long condensers and had also recourse to a three way tap with an air outlet, between the steam generator and the distilling flask, to regulate the distillation.

On 12–1–51, about 3 months after the first clip, a second harvest was made. The leaves, on air-drying in shade weighed 178 lb. and was steam distilled in a copper still during three hours as in the previous case. About 4 litres of crude distillate was isolated. On processing this crude product 2,017 gms. of total distillate (2.58 per cent on the air-dry weight of the leaves) were obtained.

PESTS AND ENEMIES

Like all exotics transferred to a new environment, the growth of *Ocimum kilimanjaricum* has to be closely watched against attack by plant diseases and pests. Mention has already been made of the fact that ants are fond of the seeds. An insect pest (unidentified weevil) cuts across the tender shoots and stalks of the young plant. While this results in loss of herbage and putting back growth, it also tends to make the plant bushy. It was also noticed that a golden bronze mottling of the leaves developed in a few plants when they were about 6 months old. It is possible that this is a manifestation of soil deficiency. Mention must also be made of attack by white ants in the field, especially with the first shower after a spell of dry weather.

FUTURE LINES OF WORK

Manurial experiments may well indicate methods of economic increase of herbage. Since it is the green leaves that are sought for, attention will have to be concentrated on cheap nitrogenous fertilizers. Also, in any scheme of irrigation of the crop, the most efficient routine of the water regime will have to be worked out. On the utilization side, the use of the oil has to be extended possibly in perfumery and also as an insect repellant and a disinfectant for which purpose its R.W. coefficient has to be determined. The residues of vegetative matter after distillation might well find a use in indigenous "Agarbatties" for perfuming and for insecticidal applications. The solvent extraction of herbage might give increased yields. On the purely scientific plane the role of the camphor in the physiology of the plants is of interest and in this connection, it is worth recording that in our experience we found the highest content of camphor in the ripe yellow leaf-litter. Also, the hybridisation of other species of *Ocimum* with *Ocimum kilimanjaricum* might result in strains with higher yield and or greater hardiness.

CONCLUSION

These results indicate that *Ocimum kilimanjaricum* is not fastidious in its soil requirement and can be grown in Mysore. Broadcast sowing is no good. Transplants do well even without irrigation. Three crops of herbage could be harvested in an year. The plant is not an annual. With a stocking of some 21,000 plants per acre (espacement of $2' \times 1'$), about 2,500 lb. of *air-dry* herbage (leaves) can be harvested per year and this could yield 50 lb. of the pure distillate. Nearly 5/7 of this or 35 lb. roughly would be the harvest of pure crystalline camphor per acre per year under these conditions.

While these figures may not look very impressive vis-a-vis modern camphor consuming industries requiring hundreds of tons of camphor, *Ocimum kilimanjaricum* still can be of considerable significance. First and obviously, at a time of national emergency, when material is vital and cost but subsidiary, the humble *Ocimum* provides the only practicable

source of camphor in this country. Second, it can well form a subsidiary earner of a modest income to the villager who could grow this in odd patches in his farm or land which would otherwise lie fallow. And, a large number of small harvests could aggreate to sizable quantities for distillation in simple stills. The crude distillate could be refined in a Central Laboratory. *Ocimum kilimanjaricum* thus promises to be the basis of an organized *Cottage industry*. Third, and of immediate interest and practicability, is that our temples and *Muzrai* institutions which use large quantities of camphor and set great store on its purity can grow their own camphor. Many of the institutions have land at their disposal and, even now, do grow in small quantities other varieties of the sacred "Tulsi" for daily worship. There should therefore be not much difficulty in growing *Ocimum kilimanjaricum* to provide the requisite camphor. Apart from questions of savings in cost, the purity of the camphor should prove a great attraction to such religious institutions.

Finally, a word may be added on the nomenclature of *Ocimum kilimanjaricum*. Kilimanjaro is an African mountain peak. And, Guerke, who named the plant spelt it as Ocimum Kilmandscharicum. Ernest Guenther in his monumental book "The Essential Oils" also spells it like-wise. It is of course well known that in German, the combination "Ja" is pronounced as "ya" and when the Germans do want to produce the sound of "ja" as in Maharaja, they have to resort to rather tortuous spelling like "Maharadscha". If this genesis of the spelling is correct, then there seems to be no reason why we should not prefer the simpler spelling, *Ocimum kilimanjaricum*.

Further work on the sylvicultural aspect of the crop and specially the possibility and economy of raising *Ocimum kilimanjaricum* as a crop in plantation will be taken up in the sylvicultural section of this Laboratory.

We are thankful to Shri M. A. Muthanna, B.SC., I.F.S. (DIP.), Chief Conservator of Forests in Mysore for his help and encouragement. Also, we are indebted to Shri S. G. Sastry, for suggesting the problem, seizing us of its importance and for the initial gift of 25 gms. of seeds.

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FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

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PART II

(*Continued from* The Indian Forester, *July 1951, page 449*)

TOGOLAND

(BRITISH and FRENCH MANDATE)

The small colony of Togo, or Togoland, to the west of the Cameroons, taken by the British during the first Great War, was the most prosperous of the German colonies. Formerly it was probably heavily wooded. At present only small remnants of forest on the north and south mountain range, and fringing river forests are left—about 1 to 2 per cent of the total land area. The rest is uninhabited degraded bush or savannah land with scattered scrubby trees. There are approximately 7,040,000 to 7,680,000 acres of inhabited agricultural country, part of which is devoted to growing oil palms. The savannah areas still contain a proportion of scattered forest containing species which would have commercial value if they were not so scattered as to make exploitation unprofitable.

There is estimated to be only 150,000 acres of virgin forest left, besides 190,000 acres of river-bank forest. This is tropical evergreen forest, with some 200 species of trees, including mahoganies (*Diospyros mespiliformis*, *Khaya klainii* and *K. senegalensis*), African teak (*Chlorophora excelsa*), *Erythrophleum guineense* (furniture wood), *Borassus flabelliformis*, as well as a large number of *Leguminosæ*. Perhaps some dozen of these trees are used to any great extent in the colony. Other species include Kapok or silk cotton tree, African rosewood or coralwood, and shea-butter tree, which furnished a fat used for butter and also in soap and candle manufacture.

As a result of the War greater demand has been made in both Togolands for timbers, etc., and saw-mills have been installed.

It is difficult to say what the true position of the Catchment areas of the rivers is like.

The German Government maintained a forestry department in the colony and some planting was done. This has been carried on to some degree by both British and French.

CAMEROON

(FRENCH and BRITISH MANDATE)

Extent of the Forest.—The total area of forests in the Cameroon is estimated at 35,000,000 acres. This is 28·6 per cent of the land area and 13·8 acres per inhabitant. The area of virgin forest, however, is only about 25,000,000 acres. The volume of virgin standing timber is estimated at $88\frac{1}{4}$ billion cubic feet, or 3,500 cubic feet per acre. Actual measurements in the most accessible areas showed that 65 per cent of the stand is of immediately utilizable species.

The forest vegetation of the Cameroon does not differ essentially from that of the Ivory Coast and the French Congo. The virgin forest at lower altitudes is typical tropical rain forest, which changes in character with increasing altitude, and finally merges into the "fog" forest in the higher mountains. The second-growth forest, which takes the place of virgin growth destroyed by shifting cultivation and fire, is characterized by the umbrella tree (*Musanga smithii*). This tree for so long regarded as worthless is now coming into utilization for pulp and plywood. The coast regions and the estuaries of the rivers are almost entirely covered with mangroves.

There are about 40 species suitable for construction and other purposes and these constitute 76 per cent of the stand. Up to the outbreak of the War the French were utilizing some nine timber species including African mahogany (*Khaya*), ebony (*Diospyros*), red ironwood (*Lophira procera*) and okoume or Gaboon mahogany (*Aucoumea*).

The mahogany of Cameroon is generally less highly esteemed as timber than that of the Ivory Coast, which is known as "Grand Bassam" mahogany.

The installation of mechanical saw-mills was begun in 1906, and two mills, with an annual capacity of 500,000 cubic feet each, are now operating in the part of the territory administered by Britain. The French mills are also now in use.

Cameroon presents excellent opportunities for a thriving timber industry. The forest resources are abundant and fairly easily accessible, and two railway lines and several navigable waterways facilitate export. While the second-growth forest is extensively cut by the natives for the purpose of clearing the ground for agriculture.

Shifting cultivation is rife in the accessible forest areas accompanied by fire. Both Britain and France have instituted Forest Services and the latter early started sylvicultural investigations of some of the chief timber species as was the case on the Ivory Coast.

FRENCH WEST AFRICA

IVORY COAST

(Colonie de la Côte d'Ivoire)

The Ivory Coast is bounded on the east by the British Gold Coast, Colony on the west by Liberia and to the north by the French Sudan and Haute Volta.

Monsieur G. Bonnet, Conservateur des Eaux et Forêts des Colonies, has sent me the following information in answer to the questionnaire. I was myself acquainted with parts of this French Colony.

> "J'ai l'honneur de vous adresser les renseignements demandes par votre lettre du 2 Novembre 1949, en ce qui concerne la Côte d'Ivoire, zone de l'ouest African placée sous mon autorité.
>
> "Les principaux fleuves sont en allant de l'Est a l'Ouest : Le Comoé, le Bandama, le Sassandra, et le Cabally.

Le Comoé	.. longueur en mille de sa source a son embouchure—500
Le Bandama	.. longueur en mille de sa source a son embouchure—500
Le Sassandra	.. longueur en mille de sa source a son embouchure—150
Le Cabally	.. longueur en mille de sa source a son embouchure—160

Le nom des principaux affluents de ces fleuves depuis leur source jusqu'à leur confluent.

Le Comoé reçoit sur la rive droite, le Tozan, sur la rive gauche, l'Irigou, le Papou, le Bafoufoué, la Ba-ya, le Betui et le Manzan.

Le Bandama, sur sa rive droite le Marahoué, ou Bandama rouge et le Sélémougou, sur sa rive gauche le Kan et le N'zi.

Le Sassandra, sur sa rive droite le Bafing et le Zô, sur sa rive gauche, la Boa, La Lobo, le Zogro, le Dibo et le Davo.

Le Cabally, ne reçoit sur tout son cours qu'une seule rivière, le Gouo.

Quant aux autres renseignements, je pense que la carte de la Côte d'Ivoire donnant les types de forêts et les courbes pluviométriques vous sera d'une grande utilité".

It is not possible, of course, to include in this Paper the numerous maps which have been sent with the replies to the questionnaire. But a mention that they exist is sufficient for the purpose in view.

Afrique Equatoriale Francaise

Monsieur J. Tariée, l'Adjoint pour l'Inspecteur General des Eaux, Forêts et Chauses du l'Afrique Equatoriale Française, has provided the following information of interest on French Equatorial Africa :

"J'ai l'honneur de vous adresser ci-jointe une carte assez recente de l'A.E.F. sur laquelle ont été reportées les limites approximatives de la grande forêt (Rain and deciduous forest).

"Les principaux fleuves et rivières de l'A.R.F. sont les suivants :

1. *Congo.*—affluents rive droite
   Oubangui
   Sangha
   Alima
   Lefini.

L'Oubangui et la Sangha sont eux-meme deux veritables fleuves dont les principaux affluents sont :

Oubangui { M'Bomou, Kotto, Lobaye

Sangha { M'Goko, Likouala aux herbes, Likouala—Mossaka, Mambili, Kouyou

2. *Ogoue.*—affluents rive droite
   Iwindo
   Okano
   Abanga
   affluents rive gauche
   Ofoue
   N'Gounie.

3. *Nyanga.*

4. *Kouilou.*—appele aussi Niari.

"Ces deux importantes rivières se jettent dans l'Ocean l'une pres de Moyumba, l'autre pres de Pointe Noire.

5. *Logone.*

6. *Chari.*

Tous deux tributaires du Lac Tchad.

"En ce qui concerne les surfaces forestières restant debout sur les montagnes et collines des cours superieurs des principales rivières et de leurs affluents, il m'est difficile de vous donner une reponse, même approximative. En effet, jusqu'à ce jour le Service Forestier n'a exerce son activitié en A.E.F. que dans les regions de Rain and deciduous forest, ou l'on peut dire que la forêt couvre vraiment le pays sans interruption.

"La region de savanes situées au Sud (Region de Brazzaville), est peu boisée et presque uniquement sous forme de galeries forestieres assez ètroites, même dans le cours superieur des rivières.

"En Oubangui-Chari, le Service Forestier n'existe que depuis 1947 et n'a pas encore étudié les regions à l'Est du Meridien 20°. La region de Babouar-Bouar Bocaranga, pres de la frontière du Cameroun, qui donne naissance a d'assez nombreuses rivières est peu boisée, le Chiffre de 20% comme toux de boisement peut-être avancé.

"En Oubangui Est peu de renseignements existent ; les vallées de l'Oubangui et de ses affluents rive droite se deboisent assez rapidement sous l'extension de la cutture du coton, par contre plus au Nord, le Massif des Bongo qui separe les bassins superieurs de l'Oubangui (rive droite), et de l'Aouk serait couvert d'une forêt de savanne assez dense, qui selon certains répresenterait la formation naturelle du pays. Plus au Nord, nous arrivons dans des peuplements d'épineux, assez bien répartis et couvrant regulièrement le pays puis au désert".

It is significant from the above descriptions, both in the Ivory Coast where I saw matters for myself, and in French Equatorial Africa how similar the French Administration has coincided with our own in the almost entire neglect of the areas of Africa covered with the so-called bush or savannah (savanne). It is only in the last few years that some of the gazetted officers of the staff have been appointed to the 'bush' areas and even at present the views of the Administration and the Governments are far from realizing or accepting the true position of the bush and its serious degrade to a condition where it will no longer be able to produce sustenance, through shifting cultivation and excessive grazing, to an increasing head of population.

Also the remark in the letter from French Equatorial Africa that according to some the bush or savanne represents the natural formation (i.e., the type of forest) of the country. He is not the first to repeat this view. The late Dr. T. F. Chipp as already mentioned, expressed this opinion or view of the bush areas in the Gold Coast in his "The Gold Coast Forest", Oxford Forestry Memoir, 1927.

It is now accepted as an erroneous point of view. Much of the so-called bush was once High Forest.

Some mention must be made here of the erosion or drying up of water supplies by the moving or creeping desert of which the Sahara affords one of the best known instances perhaps. That considerable forward advances southwards have been made during the past few centuries has been recorded by French observers in the Colonies on the southern boundary of this great desert. Records of Arab historians disclose the fact that at the end of the fifteenth century the region eastwards from Gao into the Sudan via Agades and Bilma was a fertile country with plenty of water. For, in 1497, the Emperor of the Songhai Dynasty made a pilgrimage to

Mecca with a retinue of 800 people, including his wives and women and numerous horses and donkeys. Neither of the latter animals can live long or march for long without water. This region now forms part of the desert. Further, as late as the eighteenth century, all the region to the north of Tahoua was occupied by people living in permanent villages on the line Gao-In Gall-Agades, the remains of these villages being still discernible in the sand.

At the present day, on a depth (north and south) of over 250 kilometres (155 miles), this tract of country is no longer capable of producing agricultural crops, the rainfall being insufficient. In the southern parts a sparse savannah growth affords a precarious existence to the flocks of the nomads, chiefly goats. I am indebted for some of this information to a French political officer, Monsieur A. de Loppinot, Administrateur en Chef des Colonies, who has had long service in the Niger and French Sudan colonies, and with whom I discussed this subject after our arrival at Colomb Bechar, after the crossing of the Sahara. From his personal observations and enquiries, he says that in this region the Sahara has advanced at an average rate of one kilometre a year during the past three centuries.

As regards the region to the west of this portion of the course of the great Niger river, the senior French political officer aforementioned told me that the state of affairs existing on the Gao-In Gall-Agades line also applied in the west. He stated : "The same remark may be applied to all the Sahara zone of the French Sudan, formerly inhabited by permanent villages to the north of a west to east line through Yelimani-Nioro-Gumbu-Sokolo, and now unpopulated and abandoned ; here the tract of country which has become desert is a little less than on the east, 150 to 200 kilometres ".

From observations made by myself during 1934, and by others, it would appear that the Sahara has now reached Asongo on the Niger and on a line roughly due east via Zinder to Lake Chad.

Roughly from west to east from observations I mark in the Sudan in 1947 the danger zone for the advance of the Sahara is between the latitudes of 13° and 16° from the Sudan on the east to Senegal in the west.

This type of erosion and drying up of water supplies is entirely due to the actions of man in denuding his soils by means of shifting cultivation annual firing of the country-side and overgrazing of stock by which the rainfall becomes intermittent and the spring water level in the soil sinks to a depth to which even an ordinary well can't reach.

THE BELGIAN CONGO

The following information on the Rivers and Tributaries of the Belgian Congo was given to me through M. J. de Guidt, Colonial Attache of the Ambassade de Belgique, London :—

Rivers and Tributaries of the Belgian Congo

(*a*) (1) LUABABA-CONGO length approximately 2,380 miles.

(2) TSHILOANGE from source to frontier about 90 miles, from frontier to mouth about 38 miles.

(*b*) Tributaries of LUABABA-CONGO :

On left bank Lubudi	about	206	miles
On right bank Lufira	,,	250	,,
On left bank Lovoi	,,	200	,,
On right bank Luvus	,,	206	,,
On right bank Lukuga	,,	200	,,

On right bank Luama	about	220	miles
On right bank Elila	,,	280	,,
On right bank Ulidi	,,	300	,,
On right bank Lowa	,,	250	,,
On right bank Maiko	,,	180	,,
On right bank Tshopo	,,	200	,,
On right bank Lindi	,,	356	,,
On left bank Lomami	,,	860	,,
On right bank Aruqimi-Ituri	,,	600	,,
On right bank Itimbiri-Rubi	,,	300	,,
On right bank Mongala	,,	156	,,
On left bank Lulonga	,,	112	,,

- Eloba about 130 miles.
- Dua about 130 miles.
- Lopori about 320 miles.
- Maringa about 275 miles.

On left bank Ruki about 42 miles
- Busira about 131 miles
  - Tshuapa about 400 miles.
  - Lomela about 325 miles.
  - Salonga about 280 miles.
- Momboyo-Luilaka about 320 miles.

On right bank Ubangi about 675 miles
- Bomu about 420 miles.
- Uele about 525 miles
  - Kibali about 132 miles.
  - Dungu about 110 miles.
  - Bomokandi about 280 miles.
- Giri about 205 miles.

On left bank Kasai from source to frontier about 243 miles, from frontier to mouth about 843 miles.

Tributaries of KASAI:

Tshikapa from frontier to mouth about 56 miles, from source to frontier about 320 miles.

Lulua about 206 miles.

Sankuru about 260 miles
- Lubilash about 412 miles.
- Bushimaie about 268 miles.

Loange from source to frontier about 225 miles, from frontier to mouth about 218 miles.

On left bank (of Kasai) Kwango from mouth to frontier about 412 miles from source to frontier about 343 miles.

Wamba from source to frontier about 75 miles from frontier to mouth about 325 miles.

Kwilu from source to frontier about 225 miles from frontier to mouth about 356 miles
- Kwange about 200 miles.
- Inzia about 243 miles.

On left bank (of Congo) Inkisi from source to frontier 130 miles, from frontier to mouth about 100 miles.

NILE BASIN

Semliki about 130 miles.

Kagera about 134 miles to frontier of Uganda.

Nyawarongo about 134 miles
- Kwango about 42 miles.
- Akanyaru about 87 miles.

Ruvuvu from source to frontier of Tanganyika Territory about 134 miles tributary : Luvironza about 65 miles.

Total amount of forest.—From 48 to 52% of the whole surface of the country, viz., about 300,000,000 acres of which about 275,000,000 acres are equatorial forest (Central basin and Mayumbe).

About 2,000,000 acres are cultivated strips mixed with forest.

About 23,700,000 acres are savannah sufficiently covered with woods to be included in forest area.

It is to be noted that these forests do not present any character of homogenity and that they sometimes are covered with vegetation of little importance thus making them unfit for exploitation.

From an industrial point of view, the above figures should be reduced by at least 50%, viz., there remain thus only about 150,000,000 acres presenting some interest from the economic point of view."

Mr. Guidt adds "I regret to inform you that all the information you requested is not available in a very precise form.

"Except for the first two points of your questionnaire to which precise data are supplied herewith, I can only give you approximations on points c.d. and e., of that questionnaire".

In 1943 under the auspices of the Royal African Society a small Commission was set up in London to study deforestation and erosion in Africa (and other tropical countries) and to make recommendations. The Commission consisted of Professor Stebbing, Chairman, Richard Brunot, Governor-General of Mauritania and Chad, Count P. de Briey, Territorial Administrator and Assistant Provincial Commissioner, Belgian Congo, L. Borremans, Agricultural Adviser, Belgian Embassy in London, A. Muhlenfeld, Head of the Department for West Indian Affairs, Netherlands Ministry for the Colonies, and Sir W. E. Hunt, late Lieutenant Governor, Southern Provinces of Nigeria.

Count de Briey, the Belgian Congo representative in the course of the meetings of the Commission put up two valuable notes on the Belgian Congo Forests from which the following extracts are taken :

> "The memoranda prepared by Professor Stebbing (on Destruction resulting from human activity, Causes, Consequences of Deforestation and Results) are completely convincing. They entirely agree with studies which have been made in the Belgian Congo on the problem of deforestation.
>
> "At first sight, the Belgian Congo appears to be in a privileged position as far as forests are concerned. Situated in the middle of Africa, it occupies the lowest lying ground, the part known as the central basin. Forest and water reign supreme in the bottom of this basin. The forest rises out of the marshes, and the marshes protect the forest and prevent it from being destroyed by fire or wastefully exploited.
>
> Nevertheless, deforestation is spreading in the Congo also. It is creeping along the edges of the central basin chiefly in the east of the Colony, between the Anglo-Egyptian Sudan and Northern Rhodesia".

This devastated area is, however, far less extensive than that which stretches throughout the Southern part of the Congo between the 5th and 12th degrees of latitude south.

"Year by year the forest retreats and even where it remains it changes its character. The primary forest gives way to the secondary forest, which is inhabited by Umbrella trees and other second rate timbers. Meanwhile the wooded savannah, the bush, becomes more and more sterile.

All the causes enumerated by Professor Stebbing contribute their part to this deterioration ; shifting cultivation, bush fires, grazing.

"This state of affairs was the object of very intensive study, especially in 1930 and 1931. Mr. Scaetta, and later Professor Bayens, analysed the soils from numerous parts of the Colony. Various measures were taken to combat deforestation.

"Certain measures are preventive ; I refer especially to the establishment of forest reserves in which no kind of industrial exploitation is permitted. An institution of a similar kind is the National Albert Park in the region of Lakes Kivu, Edward and Albert Edward. The fauna and flora in this Park are completely protected against any kind of destruction by man and there are even strict regulations to control thoroughfare.

"Other measures are curative. The legislation in force in the Belgian Congo permits compulsory planting work, up to a maximum of 60 days in a year, to be imposed on the native population. This measure was taken in order to ensure a certain amount of re-afforestation. In addition, the Government of the Colony has allocated large sums to ensure the re-afforestation of several of the devastated areas of the Congo, more notably those of Ruanda-Urundi and the Kivu. These regions are, in fact, particularly important, for they represent the backbone (ridge) which separates the basin of the Atlantic Ocean from that of the Indian Ocean. This backbone consists of a chain of high mountains of several thousands of metres, running in a North-South direction.

"The forests which cover the spurs of these mountains regulate the rainfall over a vast area. It is, therefore, very important that there should be no diminution in the area under forest. Several thousands of hectares have already been re-afforested since the programme began to be put into force. Among the timber species chosen for re-afforestation preference has been given to these with the most rapid growth. Not only exotic trees have been used, such as Eucalyptus and Cypress, but also indigenous timber trees found in the forests.

"Nevertheless, we cannot yet say that the problem has been solved. There are, in fact, a number of difficulties in the way, especially with regard to bush fires and shifting cultivation.

"From mere figures, we might get the impression that deforestation in the Congo, is only an imaginery danger. But, in reality, the investigations which have been made show the approximate extend of the forest zone to be 125,552,000 hectares, or 53% of the area of the Congo.

"This proportion of forest is one of the highest in existence and, if the forest were distributed uniformly throughout the Colony, there would be no grounds for uneasiness.

"But this is not so. The deforested region is almost continuous and includes a mountainous region in which erosion can cause serious devastation.

"For this reason, the precautionary measures taken by the Forest Department are justified. As I wrote in my note, these are of two kinds :—

(1) Forest reservations have been established within which no cultural exploitation may be carried out.

(2) Re-afforestation on a large scale has been undertaken with the help of State subsidies.

"I can give the following information on these two points :—

In 1938 the forest reservations in the Congo numbered 131, covering some tens of thousands of hectares.

In 1938 also, the re-afforestated lands covered an area of 8,000 hectares, but the re-afforestation campaign was only beginning".

PORTUGUESE EAST AFRICA

Mangrove forests, valuable for tanbark, abound especially along the northern coast and up the Zambesi river. In the coast region, mangrove timber, which is very durable, is used for building.

The southern part of the territory has little commercial forest, but is covered largely with thorny scrub, with occasional single trees. Fringing forests occur along the streams. Some of the bush and savannah (acacias and similar species) is an open, park-like stand of trees, a foot in diameter and 30 to 50 feet high, which yield firewood, mine timbers, and railroad ties. Much of this stand has been cut to furnish mine timbers for South Africa.

On the Zambesi river and northward are extensive areas of tropical evergreen hardwood forest. The so-called African padauk is common, as are also African sandal, African teak, ironwood, mahogany species, and many other valuable woods. Softwoods suitable for building are abundant.

It was stated, that there are ample supplies of every kind of wood needed in the province, as well as a large surplus for export. It is difficult to say at present how much this position has been altered by the last Great War, but the Portuguese do not appear to have taken much interest in the opening out and management of the existing forest wealth. It is not possible to say to what extent shifting cultivation has caused harm and the drying up of catchment areas.

Important exports are rubber, of which 500 or more metric tons were exported in the early years of the century and vegetable oil. Mangrove bark was exported in the early years of the century and vegetable oils. Mangrove bark was exported in considerable quantities (13,000 metric tons in 1907) but exports were forbidden in 1909 in order to let the forest recuperate from excessive cutting.

The chief ports of export are Quelimane, Mozambique, Hajou and Port Amelia.

TRANSLATION

Professor E. P. Stebbing,
Department of Forestry,
10, George Square,
Edinburgh, 8.

Re : Letter No. 366/49/50, 1st March last

(1) In compliance with the request contained in the letter under reference, received through the Portuguese Embassy in London, under cover of a Memorandum dated 2nd March last, I have the honour to forward to you a list of the principal rivers which flow through Mozambique, and of their tributaries.

(2) In regard to the questions in sub-sections (3), (4) and (5), it is not possible to furnish you with values as the chart of the Colonies forests has not yet been prepared.

(3) It is along the banks of rivers and the water lines that the dense forests of the higrolophic ecologic type are to be found, but the lower reaches of the rivers are generally at low level and subject to flooding and, accordingly, are devoid of trees and put under cultivation.

(4) At river deltas, particularly on the Zambeze, there are mangroves formed by marine *Avicennia*, *Bruguiera gynorrhiza*, *Rhizophora mucronata*, *Ceriops candelleana*, which form extremely dense forests.

(5) There are, however, along the river banks, some zones in which the natives have destroyed the forest in order to cultivate the land, but this should exceed 10% of the total area of the river banks covered by forests.

(6) I avail myself of this opportunity to tender to you the expression of my highest consideration.

Lourenço Marques, 4th November, 1950.

The Chef de Cabinet,
(Signed). Pedro Correia de Barros,
1st Lieut., Air Force.

Annexes :
1 list of the principal
rivers in Mozambique.

TRANSLATION

COPY

THE PRINCIPAL RIVERS IN THE COLONY OF MOZAMBIQUE

DISTRICT OF LOURENÇO MARQUES :

River Incomati.—Has its source in the Transvaal and flows into the Indian Ocean. Length from the frontier to the sea—260 km. Its principal tributaries are the *Sábiè*, the *Massitonto* and the *Uanetze*, 35 km., 70 km., and 115 km., long respectively.

Estuary of the
"Espirito Santo".—On the left bank of which lies the city of Lourenço Marques. Formed by the junction of the three rivers *Tembe*, *Umbeluzi* and *Matola*, respectively 60 km., 65 km., and 50 km., long.

River Maputo.—Has its source in Swaziland and, after flowing through that region, reaches the coast of Lourenço Marques. Length—125 km., from the frontier to the sea.

DISTRICT OF GAZA :

River Limpopo.—Has its source near Johannesburg, in the Transvaal, and flows into the Indian Ocean. Length from the frontier to the sea, 520 km. Its principal tributaries are the rivers *Elefantes* and *Chengane*, 110 km., and 400 km., long, respectively.

DISTRICT OF INHAMBANE :

River Inharrime.—Has its source near the Chengane, and flows into the Poclela Lagoon. Its length is 130 km., and its principal tributary is the Inhassune, 100 km., long.

River Mutamba.—Has its source near the Inharrime. Is partly navigable. Formerly the Copper river ('Rio do Cobre') or River of the Kings ('Rio dos Reis'). Flows into the Bay of Inhambane. Length, 70 km.

River Govuro.—Has its source at Vilanculos, and flows into the sea at Bartolomeu Dias. Length 170 km.

River Inhaliare.—Has its source at Homoíne, crosses the district from East to West, and flows into the river Inhatóeoé, at Panda. The latter river flows into the Inhamiquelengue which, in turn, is a tributary of the Inhassune. Lengths, 30 km., 60 km., 85 km., and 100 km., respectively.

DISTRICT OF BEIRA :

River Pungué.—Has its source in Southern Rhodesia, near Mount Inhanga, and crosses into Portuguese territory near the confluence of the river Mecumbeze. Length from the frontier, 310 km. Its principal tributaries are the Inhamzona, Xitora, Vanduz (150 km.) and Mutchira (120 km.).

River Búzi.—Has its source in British territory near the Mossurize through which it passes into Portuguese territory. It is 220 km., long from the frontier. Its principal tributary is the Revué which flows near Macequece and Quiteve, and is 184 km., long.

River Govongoza.—Has its source south of the Zinhumbo chain, in the sub-district of Mossurize, and flows into the Indian Ocean near the island of Boene. Length, 249 km.

River Save.—Has its source in the central part of Machona, and flows into the Indian Ocean, where it forms a delta which joins the Bay of Bartolomeu Dias. Length from the frontier, 300 km. Its principal tributaries are the Lunde and the Odzi.

DISTRICT OF TETE :

River Zambeze.—Is the main river. Flows into the Indian Ocean near the Chinde. Length from the frontier to the sea, 830 km.

River Aruángua Grande.—A tributary of the Zambeze. Has its source to the West of Lake Nyassa, crosses Northern Rhodesia. Has numerous tributaries and is 80 km., long in Portuguese territory.

River Luia.—140 km., long. Tributary of the river Mazoè (80 km.), which, in turn, is a tributary of the Luenbe (240 km.), itself a tributary of the Zambeze. It has its source in Southern Rhodesia, crosses the frontier south of the district of Tete. Has a great number of tributaries.

River Mavusi.—Is a tributary of the left bank of the Zambeze and has its source at Macanga, 140 km., long.

River Ziu-Ziu.—Connects the rivers Zambeze and Chire. 30 km., long.

River Panhame.—A tributary of the right bank of the Zambeze. Has its source in Southern Rhodesia. 50 km., long in Portuguese territory.

River Mufa.—A tributary of the right bank of the Zambeze. 70 km., long. Has its source in Mount Inhamatondo, and several tributaries.

River Luenha.—A tributary of the right bank of the Zambeze. 240 km., long in Portuguese territory, with its source in Southern Rhodesia.

DISTRICT OF QUELIMANE :

River Ligonha.—Has its source in the Inago Chain and flows into the Indian Ocean. 325 km., long. Its principal tributaries are the Muligudje (40 km.), and Namirroi (190 km.). The Ligonha separates the district of Quelimane from that of Nampula.

River Molócué.—Has its source in the upper Molócué and flows into the Indian Ocean. Forms a water fall of some 30 metres at Mount Ecupura. Reaches the sea near Moebaze. 285 km., long.

River Malela.—Has its source in the upper Molócué, and flows into the sea through a network of canals which join it to the rivers Inse and Moebaze. Is 260 km., long. Its principal tributary is the river Lice (65 km.).

River Raraga.—Has its source near Mugeba. Is 170 km., long. Its principal tributary is the Nipiode (170 km.). Reaches the sea North of Mutiba.

River Licungo.—Has its source on the Western slope of Namúli. Is 300 km. long. Its principal tributaries are the Luo, Lugela and Inhamacuria, 130 km., 180 km. and 70 km., long, respectively. The Licungo's course is about 300 km., long—equal to that of the Ligonha. It reaches the sea near Porto Belo.

River of the Good Signs or Quelimane.—On the left bank of which lies the town of Quelimane. 150 km. long. Its principal tributaries are the Licuari, Lua-Lua and the Macunbeze, 125 km., 210 km., and 110 km., in length, respectively.

River Zambeze.—Limiting the provinces of Manica and Sofala and of Zambezia (downstream from its confluence with the Chire). Its source is at Mount Caomba (near the frontier of Angola), and it flows across Central Africa from West to East, forms the Victoria cataract—the largest in the World: 200 metres deep and 1,650 wide—crosses Rhodesia, enters the territory of the Colony (of Mozambique) by the Zumbo and, flowing to the seaward of Cachomba, drops into the cataracts of Querrubassa and thence to the Indian Ocean, completing a total course of 2,200 km. Its principal tributaries are: on the right bank, the Panhame (50 km. in Portuguese territory); the Mufa (70 km.); the Luenha (240 km.) from the frontier ; the Sangadze (140 km.) ; the Mongola (50 km.) ; the Mapuza (95 km.) ; the Zangue (50 km.) ; the Mupa (50 km.), is not a tributary ; on the left bank, the small Aruângua (100 km.) ; the Luia (250 km.) ; the Maruz (135 km.) ; the Revugué (215 km.) ; the Nhangomba (50 km.) ; the Muani (28 km.) ; the Ziu-Ziu (30 km.) ; and the Chire (150 km.), in Portuguese territory.

River Chinde.—Has its source on the Zambeze, at the entrance to the Delta, and flows into the Chinde (one of the mouths of the Zambeze. It is 30 km. in length).

DISTRICT OF NAMPULA :

River Mocuburi.—Has its source in the Chinga Chain and flows into the Bay of Memba. It is 250 km., in length.

River Lúrio.—Limits the provinces of Zambezia and of Niassa (where these face the districts of Quelimane and of Lago), and then the districts of Nampula and Cabo Delgado. It has its source near Lake Chirua on the northern slope of Mount Makem and flows into the bay to which its name has been given, and its length is 570 km. Its tributaries are the rivers Malema, Muanda or Maracotela, and Nalume, 140 km., 100 km., and 110 km., long respectively.

River Meluli.—Has its source in the Chinga Chain and flows into the Mozambique Channel. It is 225 km., long.

River Malema.—A tributary of the right bank of the river Lúrio, and has its source near the heights of Namuli. Its length is 140 km.

River Lotiua.—Is a tributary on the right bank of the river Lúrio and has its source near Namuli. Length 100 km.

River Larde.—Has its source in the Chalaua lands in the south of the district, and flows into the sea south of Angoche. Its length is 90 km. The main delta of the District of Nampula, formed by the Larde and the Meluli, comprises the lines of Angoche, Mafamede, Puga-Puga and other less important ones.

DISTRICT OF CABO DELGADO :

River Rovuma.—Has its source near Lake Nyassa and flows into the sea North of Cape Delgado. It provides the northern limit of the Colony and is the most important river in the territory of Nyassa. Its length is 730 km. Its tributaries are the rivers Lugenda, Luchulingo and Messinge, 490 km., 240 km., and 185 km., long, respectively.

River Montepuez.—Has its source in Mount Quexa and flows into the Bay of Quissanga. It is 260 km., long.

River Messalu.—Has its source in the Mepalama chain, at Metarica. It crosses the region of the Macondes and flows into the sea at Mocimboa, and its length is 470 km.

River Megaruma.—Has its source to the North-East in Mount Mecumba, and flows into the basin of the Lúrio. It is 155 km., long. It has numerous tributaries, the chief being the Mucacata, the Palavala, the Necapa, the Mecorre and the Hopa, 40 km., 45 km., 45 km., 52 km., and 60 km., long, respectively.

DISTRICT OF LAGO :

River Lugenda.—Has its source in Lake Amaramba and crosses the district for the South-West to the North-East. It is a tributary of the Rovuma and is 490 km., long.

ETHIOPIA (ABYSSINIA)

The following information upon Ethiopia was very kindly sent me by Mr. Perry A. Fellows, Director of Planning, from Addis Ababa. His letter, dated 16th November, 1950, and the statement attached explained the position of this important catchment area in Ethiopia at the present time.

"It is understood that you desire some information regarding the rivers of Ethiopia.

"No survey of the various rivers of this country have been made, which are adequate for any accurate planning or design. There is no agreement on various published maps as to the name designation of most important water courses, nor have these names been officially determined, with English transliterations, so far as I know.

"A tabulation of the important rivers is attached, but the list, which I believe is from Italian sources, includes some streams which lie on the boundaries, with part of the catchment areas outside Ethiopia. The 'average flow' given on the list is probably some one's very rough estimate, because there are no long established records of stream flow gauging on any of them. It is also to be noted that the flow of the Webi Shebelli reduces to zero before it

reaches the sea. If there is any basis in actual survey for the figures given in the table of flow I cannot find it or quote the authority. There are some data on the Nile and its tributaries, which no doubt you have from Egyptian sources, which might be used as a check. Similar checks on the North and South-East, are possible if it is true that you have such data from all other countries.

"The information I have given you is informal and unofficial, and for the reasons given must be considered as approximate figures only. Since I am not informed as to the use you intend to make of the data I cannot be helpful in any further interpretations hereof. A key map is also attached."

I should appreciate having any such information as you may have bearing on all stream crossing the border.

Yours very truly,
(Signed). Perry A. Fellows,
Director of Planning.

On 30th January 1951, I received a letter from the First Secretary of the Imperial Ethiopian Embassy in London which referred to previous correspondence I had had with the Embassy in this connection and forwarding me information I had asked for on the rivers of Ethiopia. The statement sent from the Embassy was the same as that included in Mr. Fellows' letter only it had some additional information—therefore, the Embassy's statement is given below.

Rivers in Ethiopia

Rivers	Length (horizontal projection) km.	Catchment area km. 2	Average altitude of catchment area meters above sea-level	Average flow cubic meters per second	Observations
1. Baro ..	277 to Sudan Border	26·000	1600	375	Tributary White Nile.
2. Blue Nile—Abbai	998 Do.	178·700	2000	1444	
2a. Basillo 11° N. 38° 30′ E. ..	..	13·300	2500	93	The most important tributaries of the Blue Nile within Ethiopia.
2b. Jamma (Giami) (Dabus) (Addige)	..	..	2420	158	
(10° 30′ N., 35° 10′ E.) ..	..	19·790	..	..	
2c. Didessa ..	..	28·130	1890	256	
3. Gandua ..	130 to Sudan Border	6·740	1500	27	Flowing into the Atbara river 26 km. SE. of Metemma on the Sudan Border.
4. Angareb ..	217 Do.	14·310	1200	44	
5. Tacazze ..	608 Do.	67·900	1840	289	Tributary of Atbara.
6. Mareb ..	440 Do.	21·630	1400	63	Ends in swamps NW. of Assala in the Sudan.
7. Awash ..	690	55·000	1500	160	Ends in Lake Abbe, French Somaliland Border.
8. Webi Shebelli ..	1130 to Somaliland Border	125·000	1400	315	
9. Juba ..	640 Do.	133·840	1340	320	
9a. Ganale Doria ..	603	55·390	1533	106	
9b. Dawa Parma ..	640	49·670	1297	91	Joining near Dolo to form Juba.
9c. Webi ..	514	28·780	581	103	
10. Omo Botego ..	829	67·400	1750	322	Ends in Lake Rudolph.

The area covered by forests represents about 6% of the total area of Ethiopia; the forests are situated mostly in the West between Jimma, Gore, Sair, Lekemti and in the highlands of Chercher and Arussi (between the Galla lakes and the origin of Webi Shebelli). The scarcity of real forest is due to the uneven annual distribution of rainfalls; in areas where the annual rainfall reaches 60″, it is not always possible to find forests but usually savannahs with scattered trees or bushes. The real forests are found only in those areas where rainfalls are more evenly distributed through the year (Chercher and Arussi) or the total rainfalls passes the 70″ March (Gore). In the rest of Ethiopia 90% of rainfall is concentrated in only three months (July, August and September).

(*To be continued*)

GENETICS AND FOREST TREE IMPROVEMENT

BY H. S. RAO, D.SC., F.B.S.

INTRODUCTION

The importance of genetics for the welfare of mankind is being appreciated in increasing measure. It is through fundamental genetical processes that the myriad life forms arise and are perpetuated. The hope and sustenance of man on earth depends on his knowledge of the genetic material and management of the economic plant wealth and of live-stock.

From prehistoric time man has undoubtedly directed, consciously or unconsciously, the evolution of his food plants and domestic animals, by favouring the growth and multiplication of the kinds agreeble to him. The earth was already replete with them before modern man discovered the fundamental genetic laws by which life forms are perpetuated. That discovery was made in 1866 by the Austrian monk Johann Gregor Mendel although it did not become general scientific property until its rediscovery in 1900. The science of genetics has had an amazing growth in the half century since then.

Naturally, the agricultural crops were the first to receive genetical treatment to practical ends. Live-stock and horticultural crops followed suit. It was no stretch of the imagination that soon included tree plants, but a realization of the need to start a time-consuming task at the earliest possible opportunity. Tree breeding has come to stay.

EARLY EXPERIMENTS IN TREE BREEDING

Although Mendelian laws of inheritance were not known to breeders before 1900, the actual practice of deliberately breeding animals and plants date back to dim historic times.

The first mention of inherited characters in tree species dates back to 1760. Duhamel du Monceau had noticed the phenomenon in oak. In Danish forestry as early as 1765 it was considered desirable that seeds of *Pinus sylvestris* should be collected from trees of largest mast-timber size from known localities. Ph. de Vilmorin, in 1820–1840, proved the existence of races of forest trees.

The oldest known attempt at deliberate crossing of forest trees is by Klotzsch who in 1845 produced amongst other species, crosses of *Pinus sylvestris* × *P. nigricans*, *Alnus glutinosa* × *A. incana*, *Ulmus campestris* × *U. effusa*. But this passed unnoticed. Fischbach in 1848 recommended intensive work on inherited characters of forest trees, having observed the inheritance of fastigiate growth in *Quercus robur* var. *fastigiata*. Kienitz in 1879 pointed out the importance of selection for producing valuable types of trees. Luther Burbank in 1877–1887 produced hybrid walnuts with luxuriant growth. This also passed unnoticed. Chestnut breeding was first started by Dr. Walter Van Fleet in 1894 to improve nut quality.

Early this century, the importance of climatic races (provenance) came to be recognized (see Varma, 1950). The Austrian Cieslar and the Swiss Engler were the pioneers in this work just before 1900. They worked with *Picea abies*. Cieslar and A. Oppermann, about 1900, published pioneer essays on the hereditary differences of shape in individuals of the same geographic type. Augustine Henry of Dublin in 1910 urged that tree breeding should be taken up.

The first crossing to attract attention was done by Henry and Flood in 1919 between the Japanese and European larches. N. Sylven in 1909 initiated self-pollination experiments with Norway Spruce. Work on controlled pollination was started in Denmark in 1924.

The forest service at Placerville, California and A. Dengler (in 1932) used artificial pollination. Nilsson-Ehle in Sweden discovered the triploid aspen in 1935 (Syrach Larsen, 1949).

LANDMARKS IN ORGANIZED TREE BREEDING

The first large scale tree breeding project in the world was the one financed by the Oxford Paper Company of Rumford, Maine, in 1924 in co-operation with the New York Botanical Garden. In 1936 it became the North-Eastern Forest Experiment Station (Schreiner, 1950). The first centre of tree breeding came into existence in 1925 in the U.S.A. at the Eddy Tree Breeding Station which is now the Institute of Forest Genetics. Later similar work was undertaken by the Kaiser Wilhelm Institute, Berlin. The Tree Breeding Union of Germany was inaugurated in 1932. Sweden founded the Swedish Society for tree breeding in 1936, at the initiative of Prof. H. Nilsson-Ehle. Canada started it in 1938 jointly sponsored by the Biology Division of the National Research Council, the Department of Agriculture and the Dominion Forest Service. South Africa took up tree breeding in 1943. Harvard University has devoted the Maria Moors Cabot Foundation for Botanical Research to problems of forest genetics (1937). The Tennessee Valley Authority has included tree breeding among its other projects. To-day the U.S.A. and in Europe the Scandinavian countries in particular have large tree breeding projects.

Should there be any doubt that tree breeding is economically feasible, it may suffice to mention that a large part of the financial support to tree breeding in Sweden is given by the private wood industries which have benefited by it. However, tree breeding being a long range programme, is worth being undertaken by permanent national institutes and forest departments, or even on an international basis (Richens, 1945 ; Erteld, 1950). Centralization and co-ordination of research are necessary even while planning projects of local significance.

OBJECTIVES IN TREE BREEDING

The experienced silviculturist who has carried on extensive afforestation knows the good and bad traits available in a particular species, and comes to wish that if only he had such-and-such a type of tree of the species in question he could use it ever so much more advantageously. He develops this feeling for tree breeding, the intensity of which might well result in impatience for quick results.

The two categories of forest produce are timber and the so-called minor forest products. Yield and quality of timber are of major importance. Yield is determined by the genetic integrity of a species and the ecological conditions of growth. Yield of sound timber in terms of so many cubic feet may really mean the shape and branching habits, the even development of grain, etc., which are genetically determined. The yield of minor forest products may be determined by plant vigour and the particular kind of plant physiology resulting in secondary products which are both determined by heredity. The chemical techniques are available to determine the quality of products which, correlated with the tree types are of importance to the tree breeder.

Straight or twisted grain, and figured wood are probably genetically predetermined and pronouncedly developed under the influence of environment. Fastness of growth of timber or earliness of maturity in producing fruit or seed of economic importance in the case of minor forest products are both expressions of hereditary characters. Hardiness under adverse conditions of drought, heat, frost or fire damage ; resistance to fungal, bacterial or virus diseases, insect or other animal pests are all probably inherent in the various racial or provenance types, desired combinations of which traits are brought about by planned breeding.

SEED ORIGIN

Foresters are familiar with the term seed origin. However, there seems to be an incomplete appreciation of the full significance of the term. The first idea that suggests itself is the geographic location. The location is significant only when all the ecological factors are taken into consideration. This is a great complex of influences which will ever defy absolute analysis. Another concomitant idea is the kind of genetic types that thrive best in such an environment. The ultimate expression of a forest stand or an individual is the resultant of both the genetic and environmental factors. At one time the emphasis was almost entirely on the latter. It is now recognized that the final manifestation of different characters of an organism is the sum total of interaction of the genes and all that environment means. The tree breeder is primarily concerned with the genetic make-up of the strain or individual concerned.

The quality of seed used for afforestation is of utmost economic importance. Forest trees are extremely heterogeneous in quality and seeding ability. Often the more prolific seed-bearers are really inferior genotypes as has been found in teak (Laurie, 1936). The silviculturist's practice of thinning and eliminating the undesirable types, results in a limited improvement only. He aims to provide the most advantageous environment, while the breeder aims at production of types having superior heritable nature, in other words, superior genotypes.

The first requisite for planning tree improvement is to take stock of the extent of natural variability in the species in question both in the forest region in which one is working as well as in the other climatic regions where races of the species occur. Taxonomic and plant geographic information are pertinent. Taxonomic limits adopted for distinction of species are often largely a matter of taste. A study of the natural variation may reveal that many of the microspecies are merely samples of one taxonomic continuum. Often it is only by large mass collections, hybridization and cytological studies, that a valid determination of taxonomic interrelations can be made.

It is worth mentioning here two concepts regarding the races of a species and the areas they occupy. One is the Rassenkreis, which means a group of races mutually replacing each other geographically. Endemic or minor species representing locally adapted forms of the same large group are said to belong to the same Rassenkreis. Such forms are generally interfertile. The other is the Cline, which signifies a pattern of genetical variation in which the variations in a character are graded in a definite spatial direction such as north or south or according to altitudinal ranges. Cline patterns are important to the breeder because he looks for the variable characters a combination of which would prove valuable, such as cold-resistance in a high latitudinal or high altitudinal race which could be incorporated in another of vigorous growth (Varma, 1950).

Areas of intense variability are considered to be centres of evolutionary origin and they furnish a rich source of breeding material. Agricultural plant explorers are making intensive search for new genes in such areas.

CONSERVATORY OF GENES

The primeval forests and areas of maximum variability of any species are a storehouse of genes. While our preliminary judgment is made of phenotypes or apparently desirable types which are good enough for clonal propagation, our knowledge of the valuable genotypes can only be gained by progeny study. Hence we may not ignore individuals which are not so dominant looking. We may have to go back to the less spectacular types in search of valuable genes in the course of breeding work. Thus we may not seek to destroy (even if

we could) all those ordinary looking individuals, but, in our planned breeding and afforestation we develop an eye for the useful traits.

Steps should be taken to mark, preserve and catalogue mother trees of proven quality in all our forests (Inventoring). Hitherto we have evaluated such plants on the merit of the traits imparted by the maternal side only. In controlled pollination both the parents are selected. When the pollen parent does not grow nearby recourse must be had to transport the pollen to the female parent. This involves techniques of pollen collection, storage and transport (Bogdanov, 1935 ; Johnson, 1943). In short, they consist of storing pollen at low temperatures around 0°C in the dark, and not subject to excessive moisture and dryness.

EFFECTS OF ENVIRONMENT

Both genetic character and environment are important, and neither can be ignored. The one cannot compensate for a deficiency in the other. It is not possible to tell by simple inspection of a tree its suitability as a seed parent, in other words its genotype. The ultimate test of a tree must be made by a study of its progeny and by eliminating local effects of environment. It is the responsibility of the forest ecologist to determine the effect of habitat on the expression of characteristics which are basically inherent (Schreiner, 1939).

PHOTOPERIOD

Plants are profoundly influenced by the amount of light they receive. It is well known that the length of the day varies from the equator to places towards each pole. This is more pronounced in the higher latitudes where the length of the summer day is considerably longer than 12 hours. Plants of these regions have got acclimatised to such light conditions and depend on them to bring their life cycle to normal completion. Thus there are races of plants of the same species adapted to various photoperiods. They afford material for breeding types suited to either region or the intermediate zone with recombination of various desirable characteristics. This principle is perhaps not so significant to India extending as it does to relatively low latitudes. Still it is possible to envisage production of useful hybrids between forms of the same species occurring in the extreme south of India (or even in Ceylon) and forms of northern India.

FOREST TREE PHYSIOLOGY

A knowledge of the physiology of the tree species with which one wants to conduct breeding experiments is very useful. A series of such accessory studies may have to be planned pertinent to the breeder.

Kramer (1943) has summarized the objectives in forest tree physiology. The following problems come under the purview of physiology : 1. Seed storage, causes of dormany and methods of breaking it, quick determination of viability, and suitable nursery treatment. 2. Physiological bases for differences between races or strains within species, physiology of vegetative propagation. 3. Factors controlling length of growing season (e.g., photoperiod). 4. Limiting factors in extension of species beyond their natural ranges. 5. Physiology of species competition.

POLLINATING AGENTS

A knowledge of the role of insects, birds, or wind in bringing about natural pollination of the tree species in question is useful information for artificial crossing and selfing.

PHENOLOGY

Phenological data for each species, or information on the flowering season and the period of the different stages of the buds and flowers, are useful for planning pollination studies. Such data need to be collected in the various regions where a species occurs, so that when planning to cross clinal forms we should be able to know the seasonal range in which the material would be ready. Such data are already available with the Silviculturist for a number of species in New Forest.

Adversities like hail or dust storms, high winds, etc., are often to be expected and they ruin a lot of breeding material. It is well to provide protection against the elements wherever possible. It is always worthwhile to carry out a lot more bagging, crossing, etc., to safeguard against such accidents. Birds and monkeys are often a source of mischief. It is, therefore, advisable to conduct intensive breeding experiments where watch and supervision can be arranged.

GENETIC CONSTITUTION AND ITS ANALYSIS

The genotype is the sum total of heritable factors which determine the character of a plant. The determiners are called genes which are theoretical, but possibly material units located on the chromosomes of the nucleus in a linear manner. Extra-nuclear or cytoplasmic genes have also been postulated but not sufficient of them is known. The various characters are the resultant of the interaction of the genes which may be as simple as a pair of similar or contrasting genes or very numerous showing cumulative action. The so-called quantitative genes are of the latter kind and their genetic analysis is complex. Timber yield and quality are largely determined by such complex gene systems.

The progeny test is the only means of determining the gene action. The ratios of individuals showing contrasting characters reveal the number of genes involved. When multiple genes are concerned the size of progeny needed may be so large that it is impossible to raise them and keep them going up to the stage of study. As a rule only the simpler genic systems are possible to analyse. With tree plants such analysis is more difficult than with short term agricultural crops. However, where linkage occurs between a seedling or juvenile character with another adult character of economic importance, the analysis is speeded up, and many encouraging results have thus been obtained. For example the colour of the seedling leaves of the hybrid between *Acacia decurrens* × *A. mollissima* reveals the dominance of one or the other parental character in the progeny (Philp and Sherry, 1949).

CYTOLOGY

The chromosomes making up the nucleus have been demonstrated to be the physical bearers of the hereditary units or genes. The regular behaviour of the chromosome during cell division in tissue building and during the reproductive processes of the formation of the male and female gametes and their union, leaves no doubt about their significance in cell succession and succession of generations. There is a characteristic number of chromosomes in each species, which often runs through the genus and sometimes through the entire family or related families. Deviations from the normal number are accompanied by corresponding deviation in the morphology and physiology of the plant. Doubling of the chromosome number and even their multiplication severalfold has been induced by various physico-chemical agents, the best known of which is the alkaloid colchicine (Dermen, 1940 ; Eigsti, 1947–49). This phenomenon is known as polyploidy, the normal condition in the vegetative plant body being diploidy which is a result of the union of the two haploid components of the two sexes at the time of fertilization.

Artificial induction of polyploidy has been of value in producing vigorous individuals and in bringing about conditions of fertility or sterility as desired. Tetraploids are generally more vigorous than the corresponding diploids, and triploids have often desirable economic properties although showing a high degree of sterility. Amphidiploid hybrids (hybrids having their chromosome number doubled rendering them fertile) are one of the chief hopes of the forest tree breeder because they offer the promise that first generation hybrids possessing superior characteristics may be rendered true breeding at a single step. This is especially important with species which are difficult to propagate vegetatively (Duffield, 1942). In Sweden triploid and tetraploid strains and individuals have been produced in spruce, aspen, birch, elm, alder and oak (Gustafsson, 1949). Particularly in case of species which are propagated vegetatively, desirable polyploid types can be multiplied on an extensive scale for plantation purposes, thus bringing about a uniform stand of common heredity subject only to the degree the environment can affect them. Such a plantation provides the means of evaluating the genotype as well as the influence of the environment.

GENETIC METHODS IN PRODUCING VIGOUR

Another method of increasing productivity is the utilization of hybrid vigour. This requires a judicious selection of the two parents. They may be from different races or climates, even between two related species or genera. Another special type is obtained by crossing two inbred individuals. If the inbreeding has been done in several successive generations the degree of hybrid vigour on crossing them is very pronounced. The product of two single crosses, say $A \times B$ and $C \times D$ can be further utilized in a double cross by which great hybrid vigour, productivity and uniformity are ensured. This method has been the standard practice in producing commercial seed of maize (Hayes and Immer, 1942). Obviously, an application of such methods to tree plants is not feasible. However, a beginning has already been made in developing inbreds and their crosses in America (Stout and Schreiner, 1933). The importance of building up such breeding material in permanent national institutes should not be lost sight of. Particularly, with forest species of short rotation such methods should be practicable within a reasonable number of years.

METHODS OF FORCING EARLY MATURITY

There are moreover various means of making short-cuts in bringing about early maturity of seedling generations. Strangulation, partial girdling, root-pruning, phosphatic manuring, freezing, artificial illumination, grafting on dwarfing stock are some of the techniques available for hastening maturity, by which the breeder hastens the time taken for successive generations.

VEGETATIVE PROPAGATION

Methods of vegetative propagation are an invaluable tool for the plant breeder. Having made selections of the best individuals or so-called plus-trees the next step is to propagate them without altering their heredity and try the resulting clones in plantations where an estimate of the genotype is made after eliminating variation in development due to environment.

A species may lend itself to easy propagation or not according to its inherent physiological ability to regenerate itself into new individuals from stem cuttings, root cuttings, root suckers, etc. With due consideration to the physiology of the species, the season, and physical conditions for propagation, a high degree of success can be attained with many species. At least one case is known of a correlation between vegetative propagation and sex, viz., in red maple (Snow, 1942). Such a correlation would be useful in working with dioecious species.

A modern development is the use of chemicals called hormones which induce root-formation. There are several such chemicals known. The optimum concentration to be used has got to be found out. Although the best hormones and their concentrations have been worked out for a number of temperate species (Thimann and Rogers, 1950 ; Avery and Johnson 1947), practically nothing is known of the rooting response of Indian forest species.

Vegetative propagation is also plant breeding in a wider sense and where convenient it may be possible to use it so extensively that genetic improvement may even be deferred for a time. Vegetative propagation seeks to preserve those genes that are found to have economic value. When a great succession of vegetatively propagated generations are raised there is a possibility of the deterioration of the clones, but that is not likely to happen with tree species which are long lived.

Budding and grafting are only extensions of the vegetative propagation. The scion material establishes organic union and obtains sustenance from the rootstock while retaining its genetic individuality. Undoubtedly, the effect of rootstock on scion has been noticed in their compatibility relationships, quantitative development and physiologic responses such as earliness, resistance to diseases and pests, etc. In spite of the claims of a school of Russian scientists who claim profoundly to modify heredity by what they call graft-hybrids, such a phenomenon has not been confirmed. Certain apparent cases of hybridity have other explanations like chimeral unions of what may be called mechanical juxtapositions of tissues of stock and scion. Whatever the reality of the Russian claims may be, there is a certain veil of vagueness, without lifting which they cannot be justly evaluated. For the time being it is well to regard the scion as remaining genetically unchanged.

The techniques of grafting and budding are amply described in standard works of horticulture. For a critical evaluation of "graftage" the paper by R. H. Roberts may be consulted (Roberts, 1949). Many practical methods of grafting and budding are common knowledge of trained gardeners ('malis') in India. Among improved techniques of grafting tree plants mention may be made of "bottle-grafting" (Jensen, 1942) in which the lower end of scion which is approach-grafted to the stock is kept immersed in a bottle of water or nutrient solution to keep it alive till the graft union takes place. The use of growth promoting hormones to accelerate graft union is a recent practice which needs to be tried out with various species.

Grafted plants grown in large tubs or pots are extensively used for forcing and crossing under greenhouse conditions. Interspecific and intergeneric stock-scion combinations are often successful which can be used as such or as aids to hybridization studies.

THE VARIOUS PHASES OF TREE IMPROVEMENT

The different phases of tree improvement may now be stated as follows :—

(*a*) *Plant Introduction.*—The first step in plant breeding is assembling a wide range of germ-plasm or breeding material. This may include races, clines, related species and genera of the wild population from a wide geographical range. Botanical gardens and arboreta normally collect an assortment of such forms sometimes including some monstrosities out of sheer curiosity. Plant Introduction Gardens of American Experiment Stations serve the purpose of conserving germ-plasm. The collections are often the result of elaborate and costly plant exploration trips both within the country and abroad. Such plant introductions serve in the first place to bring about their assembly in one centralized place and in the second place they are given a chance to get acclimatized. Progressive acclimatization is itself a principle in plant

improvement in that the plant forms from unlike climates are gradually broken in through intermediate stages or otherwise they would be killed outright. Arzybasev (1939) has described the progressive adaptation of trees from the Pacific coast of North America by first planting the first generation seed in Alaska, the second in Finland and the third in Moscow. Similarly certain European apple varieties introduced in the milder climate of Australia for decades, have been successfully introduced in turn in the relatively warmer climate of Mysore plateau. Some Russian writers seem to believe that a hostile environment has a directive influence in bringing about mutations favourable for survival in the new environment. Such a belief is not commonly accepted.

(*b*) *Selection.*—The assembled plant material is subjected to sifting by selection. The simplest though least precise method is mass selection, that is, seed from superior trees is bulked and sown. In the case of agricultural crops this process is repeated for several generations and this is practised only when more intensive methods cannot be undertaken. Roguing of the undesirables is done from the seed-bed stage onwards. Under mass selection the population remains genetically heterogeneous. Nevertheless there is brought about an overall improvement by eliminating obviously poor types.

(*c*) *Mother Tree Selection.*—More satisfactory than mass selection is mother tree selection, although heredity only from the maternal side is thereby controlled. However, the high frequency of good types in a natural stand gives ground for confidence as to the heredity of the father as well (Lindquist, 1948). The discovery of a single elite tree may be worth as much as many years of tree breeding work. Mother tree selection is the only method practicable for seed collectors in the forests. In selecting tall trees the use of a binoculars will suggest itself as a useful aid.

(*d*) *Individual Plant Selection.*—This is the most precise method if not always practicable. Selected individuals of promise are selfed and/or pollinated with chosen male parent pollen.

(*e*) *Hybridization.*—After selecting the most promising genotypes the breeder wants to combine the good qualities of different individuals in one superior synthetic variety. Crossing between varieties is usually easy and the hybrids are generally fertile, but wider crosses are very difficult to effect, often quite sterile. A large number of interspecific crosses have been achieved, many of them of economic value possessing hybrid vigour, e.g., variety Stabler of *Juglans nigra*, L. × *J. regis*, L. Rapid growing species hybrids have been raised of larch, birch, aspen and alder (H. Johnsson, 1949).

Hybrid sterility: Hybrids from wide crosses show often a high degree of sterlity. This may be either chromosomal or genetic. In the first case meiotic aberrations prevent the formation of functional gametes. In such cases fertility may be restored by suitable alterations in chromosome numbers. Artificially inducing doubling of chromosomes of the hybrid by means of colchicine brings about the amphidiploid condition with complete fertility. Genetical sterility, however, is a complex matter and cannot be removed so simply.

(*f*) *Progeny Testing.*—This is the only sure means of evaluating the genotype of the parent trees. If a selfed progeny grows into preponderantly desirable uniform

stand, the mother tree is a genuine elite or genotype. The progeny tests should be repeated during a series of years in order to follow development in detail. The records should include observations on the type of branching; number, size and angle of branches; notes on growth and heartwood development, powers of self-pruning, seed-setting; straightness and susceptibility to diseases and pests.

Hybrid progeny need similarly to be selected. The first generation hybrids (F_1) are uniform and more or less intermediate between the parents. Segregation and recombination occur in second generation (F_2) and it is this generation that provides a very wide diversity of material for selective breeding. Therefore, the procedure is that (1) a small F_1 progeny is grown, (2) a large second generation population is raised, and (3) selective breeding is continued with the most promising individuals of the second generation (Schreiner, 1937).

An analysis of the numerical ratios of characters appearing in the progeny of an hybrid (F_2 segregation) gives a clue to the number of genes involved in producing those characters. It will be necessary to work with as large a number of offspring as possible since the number of gene combinations is extremely large. The ideal ratios are rarely ever met with, but the goodness of the fit of the observed ratios to the theoretical can be computed by statistical means (X^2, pronounced Chi-square test). Linkage relations of sets of genes complicate matters, but appropriate statistical techniques have been devised to compute the intensity of linkage.

Correlation of juvenile seedling characters with adult tree characters of economic value, if established, is an invaluable guide in recognizing desirable genotypes and phenotypes to be used for selection, vegetative propagation, or in further breeding.

(*g*) *A System of Rating.*—The best trees are usually selected by an eye estimate. While the observant eye gathers a comprehensive impression of a large number of characters at once, it is well to make an analytical approach to the problem. In any one species, it would be desirable to make a sort of catalogue of varying characters that can be distinguished easily, and it should be possible to assign marks, say on a scale of 5 ranging from '5' considered as best (or worst, as may be convenient) to 1 as the poorest. Then by adding up the marks under each item of character one can select those scoring the highest marks.

For instance, the following characters of a tree species might be catalogued: shape, whether symmetrical and desirable or not; branchiness, of the desirable kind or not; leafy crown of the desirable type or not; overall vigour; straight or twisted grain; dominant or suppressed under competition; adaptation to rich or poor soil locations; amount of seeding; earliness or lateness in seeding (in the age of the plant); frost and disease resistance when exposed to such adversities. The simple system of rating of 5 can be used with each of these items and the marks totalled up. With some experience with the particular species in question, the standard for the 5 degrees of the rating can be arrived at. The ratings for the different characters can be written in a definite order, just as the tailor takes down the dress measurements in a certain order. This system has worked well with genetical investigations on horticultural plants (devised at the University of Minnesota) like strawberry and can be adopted to any other species of tree or herb (or animal !). These

ratings can further be statistically treated. Thus even without elaborate actual measurements of physical quantities (height, girth, number of branches, etc.) a reasonably accurate system of ratings useful for statistical computation can be devised. If such data are collected on the same day by the same man (or team) a high degree of accuracy is likely, as the standard ratings 1 to 5 are primarily mental concepts. Forest officers would do well to train themselves in this technique of mentally assigning marks for individual characters instead of depending on a total visual impression.

A rating of 5 is found to work out better than a rating of 10 (or percentage idea) since 3 is the middle number and there is only one intermediate number on either side (viz., 2 and 4) other than the extreme values of 1 and 5.

The trees scoring high will be the 'plus' trees, the term used in Scandinavian tree breeding work.

(*h*) *System of Records.*—A plant breeder will be faced with the problem of keeping records as soon as he has begun his work. A concise system of notation that ensures ease of interpretation and accuracy of record is desirable. The Minnesota method devised especially for field crops is given below (Hayes and Immer, 1942, p. 80) :—

"Minnesota Records

"1–20–1..	.. Selections
11–20–1..	.. Crosses
111–20–1..	.. New Introductions

In this method, I, II and III stand for individual plant selections, crosses and introductions, respectively ; 20 represents the year in which the selection, cross, or introduction was made ; and the final number represents the particular selection, cross or introduction. Crosses are given a selection number only after having been shown to be homozygous. Parental and F_n populations are numbered by carrying row numbers for the current and preceeding season until homozygosity is reached. When the method of carrying row numbers for years is used in the planting plan, a pedigree can be completed when desired. The method often used by the workers in the U.S. Department of Agriculture or in State experiment stations is given here where F_1 = A, F_2 = A–1, A–2, etc., F_3 = A–1–1, A–1–2, etc., according to the number of selections grown.

First year = II–18, A
Second year (generation) = II–18, A–1, A–2, etc.
Third year (generation) = II–18, A–1–1, A–1–2, etc.

Selections of crosses, when given series numbers, after reaching homozygosity, are designated II–18–1, II–18–2, etc., according to the number of selections made.

Alberta System

(Modification of Minnesota System)

I = Introduction
S = Selection
H = Hybrid.

Otherwise the method of numbering is similar to that used in Minnesota".

It is worthwhile opeing well-bound (leather-bound) registers for recording data which will have to be preserved for a great many years. A numbering machine will be found to be a handy tool for consecutive numbering of selections, pages, etc.

(*i*) *Testing Methods.*—Having obtained through breeding a number of new forms, the next step is to grow them in stands to determine their performance. Seedling plants from different provenances are also similarly laid out for study. Langer (1939) suggested dividing the seed for progeny testing into seed-size lots and sowing them separately so as to evaluate any initial advantage that may accrue from higher seed weight.

Statistical methods must be used in designing tests and in interpreting results. The lay-outs used at present for varietal trials are probably adaptable to forest conditions.

Randomized blocks according to Fisher and the incomplete block method advised by Yates (see Johnsson, 1949) may be principally used. Day and Austin (1939) have described a cubic lattice design of lay-out suited to forest tree testing. Adequate testing as in the case of agricultural crops involves a large land space and the use of large numbers of trees, which may often be impracticable, but are nevertheless justified.

SEED ORCHARDS

Seed orchard is the term used by Scandinavian tree breeders for special plantations where seed of high genotypic quality is produced for raising forest stands on an extensive scale. This consists of grafted trees trained to form open, wide-branching crowns to produce large quantities of seed that is easily harvested. The rootstock used is of a dwarfing variety which besides forming a compact sized tree, also brings about early flowering and seeding of the scion grafted on it. Such dwarfed, regularly and abundantly flowering individuals are found not rarely in most forest tree species (Lindquist, 1948). The scions are taken from elite tree of proven genotype. The size of the seed orchard is calculated to meet the requirements of seed, of the region it is intended to serve. The difference between a fruit orchard consisting also of grafted trees and the tree seed orchard lies in the fact that while the fruit is the ultimate desired product of the fruit orchard, it is the true breeding, high quality seed that is produced in the seed orchard. This seed is used to raise the individuals of the genetically improved forest stand.

The Scandinavian forest scientists (Gustafsson, 1949) have proposed the building of two types of seed orchards : (1) the clone plantation, built upon a number (20 to 30) of so-called plus-trees selected in nature and propagated by grafting on dwarfing rootstock whenever available, and (2) the seedling plantation, built upon seed arisen in a clone plantation after free hybridization. By special treatments the seedling material is forced to premature flowering.

CONCLUSION

Although planned tree breeding has a history of little over two decades a tremendous amount of work has already been accomplished in the U.S.A. and the Scandinavian countries. Practically all progressive countries of the world have started projects in tree breeding. Genetics in forest tree improvement became one of the recognized subjects at the III World Forestry Conference held in Helsinki in 1949. There is already a wealth of literature on the subject. The author of this paper has collected references to over a thousand publications on forest genetics, techniques, etc., pertinent to forest tree breeding. The Plant Breeding Abstracts (PBA), a monthly publication of the Commonwealth Agricultural Bureaux has been regularly abstracting the world's literature on plant breeding including forest plants. The American Biological Abstracts similarly includes abstracts on tree breeding.

The Indian Silvicultural Conferences have urged the importance of starting tree breeding work. A beginning must be made immediately. The immensity of such a programme of work, however, should be realized. It cannot be a one-man activity. There are no doubt a large number of silviculturists and forest officers vitally interested in taking up tree improvement work. Nevertheless a strong central department of this activity should be organized. We have seen that in progressive countries there are Tree Breeding Institutes established. Enormous resources and proving grounds will be necessary in course of time. Regional stations will inevitably develop. The personnel engaged in this work should get conversant with similar activity to other countries. Indian silviculturists have proved their competence in the management of tree life. It will be worth their while to devote their nurture and care to pedigree material.

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PRACTICAL DIRECTIONS FOR THE PROPHYLACTIC TREATMENT OF TIMBER, BAMBOOS AND PLYWOOD FOR PROTECTION AGAINST INSECT DAMAGE

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The annual losses due to insect damage of untreated timber, etc., during storage run into very high figures. For the last few years, the Branch of Forest Entomology has been engaged in research on finding out suitable prophylactic treatments, both by "natural" means and by the use of prophylactic insecticides. Although experiments are still in progress, our results have reached a sufficiently advanced stage to enable me to tentatively give the following practical directions for general use. In drawing up these directions, I have also taken note of some results obtained elsewhere.

It should be emphasized that the object of these directions is to provide temporary immunity for a few months against insects (*e.g.*, borers, termites, etc.), during essential periods of storage, as for example, storage of logs in forests before transportation to the factory, and so on. The treatments here recommended do *not* secure permanent preservation, nor do they destroy the existing infection.

(A) GENERAL

1. Keep the store-yard clean of refuse and useless timber.

2. Inspect at regular intervals. Any attack noticed should be immediately attended to. Either treat or remove the attacked timber.

3. Store in such a manner that all sides of the stored timber can be readily inspected and, if necessary, treated. Have narrow lanes for this purpose.

4. (*a*) In giving prophylactic treatments, it should be borne in mind that, for obvious reasons, timber is far more liable to attack during the peak periods of the emergence of the adult insects than during the ebb and non-emergence periods. This applies in particular to the borers ; less so to the termites which are active throughout the year, though particularly so during the wet season of June to September.

(*b*) The emergence periods vary with the climate and season ; also with the species of insects which, in turn, may vary from one species of timber to another. In North India, usually no emergences occur during the cold period (mid-November to mid-February).

(*c*) The practical outcome is briefly this : During ebb and non-emergence periods, a single prophylactic treatment should be enough. But during and immediately before the emergence periods, prophylactic treatments may need repetition, say every two months (see Nos. 8–10).

(B) FRESHLY FELLED AND FRESHLY CONVERTED TIMBER

(*i*) "*Natural*" *methods*.—

5. Storage of logs in "open" (*i.e.*, without any tree canopy) is generally preferable to storage under forest shade, as the latter method induces an increased attack of pinhole borers and heartwood borers.

6. Logs should be debarked (remove bark and bast) as early after felling as possible, as leaving the bark in tact renders the logs liable to attack by serious heartwood borers. [Debarking increases the liability to attack by powder-post beetles, but these usually attack only the first inch or two of the sapwood : this portion is usually removed during the normal fashioning of log under conversion.] Generally, logs may be debarked within two months of felling. But in highly suceptible species, *e.g.*, the *salai* (*Boswellia serrata*) debarking must be done immediately on felling : serious heartwood borers lay eggs in dead bark, not in the living one.

7. Storage of logs in fresh, running or frequently changed water for four to five months (in a log-pond) confers immunity to the subsequently converted planks against borer attack.

(*ii*) *Insecticides.*—

8. In recently felled logs, converted timber (planks) and bamboos, a liberal spraying of a 5 to 10 per cent water emulsion of D.D.T. on all sides will keep off insect attack for several months, under protection of a roof : in the open, rain may wash away most of the D.D.T., necessitating fresh spraying.

9. Immunity for several months to recently felled logs and bamboos can also be provided by a liberal spraying of a water emulsion or dispersion of 0·5 to 1 per cent gamma benzene hexachloride (abbreviation : B.H.C. or H.C.H.)*. A second spraying may be desirable (see No. 4*c*). There are indications that B.H.C. may prove to be superior to D.D.T.

10. (*a*) While exact economics of the spraying of D.D.T. and B.H.C. have not been worked out, these methods are relatively cheap. An 80 to 90 per cent pure D.D.T. powder costs about Rs. 3/- per pound, and a 50 per cent B.H.C. (0·5 per cent gamma B.H.C.) "wettable powder" about Rs. 2/- per pound. These powders are made into water emulsions and sprayed. A thin uniform layer of deposit all over is preferable to a thick irregular layer.

(*b*) These insecticides are available in several commercial brands. D.D.T. may be obtained from Geigy Insecticides Ltd., Bombay. B.H.C. is available in several brands, *e.g.*, Hexadole (Geigy's), Gammexane or 666 (Imperial Chemical Industries) and Hexyclan (N. V. Noury & van der Lande, Calcutta).

(*c*) Except in large scale storage, no expensive spraying equipment is required, cheap hand-sprayers being quite suitable. The chief point to remember is that for closely stacked timber the most effective nozzle is the one which should produce a dense fog of the ejected emulsion ; this ensures uniformity of spread as well as economy in the quantity of the insecticide used.

(C) PLYWOOD PANELS

11. Plywood panels during storage can be protected for several months against the powder-post beetles (*Lyctus* spp.) by spraying a 5 to 10 per cent D.D.T. or a 0·2 to 0·6 per cent B.H.C. emulsion. To economise spraying cost, bundle a number of panels, tie them tightly in metal hoops and spray all the edges and the outer surfaces of the two end panels.

(D) ANTI-TERMITE MEASURES

12. Before laying out the storage ground, inspect it thoroughly and have it well cleaned. If it is infested by termites or there are termite mounds in the vicinity, the following treatments may be followed.

* Since writing the above, we have found that B.H.C., in as low a strength as 0·33 per cent gamma isomer, provides complete protection to bamboos in storage under a roof for 13 months against the *ghoon* (*Dinoderus* spp.); per cent D. D.T. was far less effective.

(*a*) Spray the ground thoroughly with a 4 per cent water emulsion of D.D.T. or a 0·2 per cent water emulsion of benzene hexachloride. Or, if this is not possible, at least soak the ground well with used fuel oil.

(*b*) Termite colonies in mounds can be destroyed as follows :—Make several holes in the mounds and through these pour, by means of a funnel, either 1 per cent D.D.T. or 0·2 per cent B.H.C. water emulsions at the rate of 2 gallons of the emulsion per 10 cubic feet of the mound volume, or roughly the following amounts for various heights of mounds. For 1 to 3 ft., 1 gallon ; 4 ft., 5 gals. ; 5 ft., 10 gals. 6 ft., 18 gals. and 7 ft., 27 gals.

13. The anti-borer spraying of timber as recommended above will also provide some immunity against termites, but the problem must await further research.

14. In termite infested grounds, suitable dunnage is important. Do *not* store timber directly on the ground, but place it on high skids (at least 18 inches from the ground) of cement or iron or treated wood. If logs are used as skids, treat them with 5 to 10 per cent D.D.T. or 0·5 to 1 per cent gamma B.H.C. before use, and at regular intervals thereafter. Anti-termite shields are also useful.

PULPING OF *ILLUK* GRASS (*IMPERATA ARUNDINACEA*) BY SODA AND MONO-SULPHITE PROCESSES

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SUMMARY

At the request of the Ceylon Government, investigations were carried out at the Forest Research Institute, Dehra Dun, on the pulping of *illuk* grass (*Imperata arundinacea*) by mono-sulphite and soda processes with a view to ascertaining the respective economies of the two processes. The sample of grass was supplied by the Ceylon Government.

The investigations have disclosed that the cost of chemicals required for pulping of the grass by the mono-sulphite process is 38% more than that required by the soda process. Of the two methods of digestion, namely "overhead" and "fractional" as applicable to the soda process, "fractional" method of digestion appears to be more suitable as well as more economical for pulping of *illuk* grass.

INTRODUCTION

Investigations on the pulping of *illuk* grass (*Imperata arundinacea*), by the soda and the mono-sulphite processes, had been undertaken at the Forest Research Institute, Dehra Dun, at the request of the Ceylon Government[1] with a view to ascertaining the respective economics and suitability of these two processes as applied to this particular species. The sample of grass, employed in the investigation, had been forwarded by the Director of Industries[2], Colombo, and was received at Dehra Dun on November 30, 1949.

DESCRIPTION

The sample of grass, received from Ceylon, weighed about 15 lb. and consisted of dried culms of grass about 4 feet long and varying in colour from cream to pale brown. A note on the growth, distribution and uses of this grass by the Forest Botanist, Forest Research Institute, is appended at the end of this report (Appendix I).

CHEMICAL ANALYSIS OF GRASS[3]

A representative portion of the sample of grass was first cut into small lengths and then was reduced in a laboratory disintegrator into a meal which passed through a 60 mesh sieve and was retained on a 80 mesh sieve. This meal was used for carrying out the chemical analysis. The results of the analysis, expressed on the oven-dry weight of the sample of the raw material, are given below :—

		%	
1.	Ash	4·81	(of this 3·1% is silica)
2.	Cold water solubles	6·06	
3.	Hot water solubles	8·42	
4.	1% NaOH solubles	40·17	
5.	10% KOH solubles	59·03	
6.	Alcohol-benzene solubles	2·43	
7.	Ether solubles	2·07	
8.	Pentosans content	19·56	
9.	Lignin content	24·32	
10.	Cellulose	50·17	

The results of the analysis are more or less similar to those obtained in the case of other species of *gramineae*, such as *Saccharum spontaneum*, *Saccharum arundinacea*, etc., tested at the Forest Research Institute and found suitable for paper-making.

DIMENSIONS OF FIBRES

A microscopic examination of a sample of pulp, obtained from *illuk* grass, was carried out to determine the length and the diameter of the ultimate fibres and gave the following results :—

		Length mm.	Diameter mm.
Maximum	..	3·36	0·0160
Minimum	..	0·50	0·0040
Average	..	1·26	0·0097

The long fibres were very few. The shorter fibres predominated. The fibres were of the long slender type with tapering ends and resembled those of *Eulaliopsis binata* (sabai grass) which is one of the staple raw materials of the Indian paper industry. But the average length of the ultimate fibres of *illuk* grass is much shorter than that of sabai grass which is 2·03 mm. This would detract from its value as a paper making raw material. Short-fibred pulps generally produce paper of inferior quality unless mixed with a small percentage of some long-fibred pulp such as bamboo pulp. As a paper making raw material, *illuk* grass is therefore much inferior to sabai grass.

PREPARATION OF MATERIAL FOR PULPING

The sample of *illuk* grass was freed from extraneous matters, such as roots, leaves, etc., and then cut into small lengths about ¾″. The chipped grass was afterwards seived through a 60 mesh seive to separate out dust or debris which was rejected. The sample thus freed from the dust was used for all pulping experiments carried out in the laboratory.

PULPING PROCESSES

Digestions of the grass were carried out by the following processes :—

(1) Soda process,

and (2) Mono-sulphite or neutral sulphite process.

In the soda process the active digestion chemical employed is caustic soda. Pulping experiments were carried out both by the conventional "overhead" method of digestion and the "fractional" or two-stage method of digestion. In the latter method cooking liquor used in the pre-digestion or the first stage of digestion is the brown or lignin liquor collected from the second stage of digestion after the completion of the cooking operation. The pre-digestion is carried out at a low temperature and pressure with a cooking liquor of low concentration. In the second stage of digestion fresh liquor, composed of caustic soda, is used and the digestion is carried out at a high temperature and pressure. The concentration of the cooking liquor employed is also higher.

The soda process is at present employed for pulping of esparto in the U.K. and sabai grass in India.

In the mono-sulphite or neutral sulphite process the cooking liquor is a solution of sodium sulphite containing in addition a small proportion of an alkali such as caustic soda or

sodium carbonate. This process is reported to have been found suitable for pulping cereal straws. Investigations are, however, still in progress to develop, from technological as well as the economic view point, the optimum procedures and products. As far as is known the neutral sulphite process is not employed commercially at present for the reduction of grasses to pulp. It is stated that it is employed in a mill in Holland for the production of bleached neutral sulphite pulp from cereal straws.

RESULTS OF PULPING EXPERIMENTS

The results of the pulping experiments are set out in Tables 1, 2 and 3 at Appendix II. Physical characteristics of mono-sulphite and soda pulps, both unbleached and bleached, are given in Table 4 (Appendix II). Physical characteristics of pulps after beating in the Lampen Mill, in the laboratory, are also included in this table.

For comparison of the economics of the two processes an "Index figure" of cost has been calculated for each process. The resulting index figures are also tabulated in Tables 1, 2 and 3 (Appendix II). The "Index figure" represents the unit cost of chemicals for the production of bleached pulp from the grass and has been calculated as follows :—

$$\frac{\text{cost of 100 lb. of grass} + \text{Cost of NaOH or } Na_2SO_3 \text{ (required for pulping 100 lb. of grass)} + \text{Cost of bleaching powder (required for bleaching pulp obtained from 100 lb. of grass).}}{\text{\% Yield of bleached pulp.}}$$

Prices of chemicals taken in calculating the "Index figure" of cost were the prevailing prices at the manufacturing site in Ceylon and were supplied by the Planning Division[4], Department of Industry. To be on the conservative side, soda recovery in the case of soda process has been taken at 60% for calculating purposes. With a modern soda recovery plant the recovery should not be less than 85%. Recovery of chemicals is not possible in the mono-sulphite process.

DISCUSSION OF RESULTS

It will be seen from Table 1 (Appendix II) that well-cooked pulp has been obtained only in experiment No. 4. The digestion conditions employed in this experiment may be considered the optimum conditions of digestion for the mono-sulphite process. Similarly for soda process conditions of digestion employed in experiment No. 1 in Table 2 and in experiment No. 4 in Table 3 can be considered the optimum conditions of digestion for this grass for "overhead" and "fractional" methods of digestion respectively. From the data of experiments set out in Tables 1, 2 and 3 it will be observed that temperature, time and chemicals employed in the soda process, "fractional" method of digestion, are the lowest of all. The colour of the bleached pulp in this case is also white. On the other hand temperature, time and consumption of chemicals are the highest in the mono-sulphite process (Table 1) and yet the colour of the bleached pulp is of dull shade. The striking feature of the mono-sulphite process is the markedly high yield of pulps. This advantage is, however, offset by the high consumption of chemicals, higher temperature, more time and the very low colour of the bleached mono-sulphite pulp. This will naturally result in higher cost of production in the mono-sulphite process as is evident by the "Index figure" of cost. As will be seen from Tables 1, 2 and 3 the "Index figures" of cost for mono-sulphite, soda "overhead" and soda "fractional" are 0·155, 0·119 and 0·09 6respectively. In other words cost of production will amount to 38% more for the mono-sulphite pulp than for the soda ('fractional') pulp.

As regards physical characteristics, it will be seen from Table 4 (Appendix II) that mono-sulphite and soda pulps possess more or less similar strength properties[5]. The colour of the mono-sulphite bleached pulp, as already stated, is, however, low as compared to soda bleached pulps. On the whole, the quality of product obtained by the soda process ('fractional') is slightly superior to that obtained by the mono-sulphite process.

CONCLUSIONS

From the observations made above, it would appear that the soda process is more economical for pulping *illuk* grass (*Imperata arundinacea*) than the mono-sulphite process. The cost of chemicals, required in the mono-sulphite process, is 38% more than that required in the soda process. Of the two methods of digestion of the soda process the "fractional" or the two-stage method of digestion has been found more satisfactory and more economical for pulping this grass. This method of digestion has already been found satisfactory for pulping sabai grass, esparto and bamboo. It is recommended for the pulping of *illuk* grass.

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1. Letter No. G 101, dated the 16th March 1949, from the Ministry of Industries, Industrial Research and Fisheries, Colombo.
2. Letter No. PW/417/5, dated the 25th April 1949, from the Director of Industries, Colombo.
3. The standard methods of the Technical Association of the Pulp and Paper Industry (TAPPI), U.S.A. were employed for chemical analysis of grass.
4. Letter No. PA/4/7/5 of 25th April 1949.
5. For the determination of the strength properties of the samples of pulp, standard test sheets were prepared on a British pulp evaluation apparatus, as described in the Second Report of the Pulp Evaluation Committee to the Technical Section of the Paper Makers' Association of Great Britain and Ireland.

APPENDIX I

A NOTE BY THE FOREST BOTANIST, FOREST RESEARCH INSTITUTE, DEHRA DUN

Imperata cylindrica (Linn.) P. Beauv. Syn. *Imperata arundinacea*, Cyrill

DISTRIBUTION :—

India, Ceylon, Burma, Java, Sumatra, Malaya, Tropical Africa, Philippines and the East Indies.

This species is one of the most widespread in the tropics and throughout the hotter parts of India, because of its very efficient means of reproduction, both vegetatively and by seeds. The numerous light, plumed seeds are dispersed by wind and are capable of travelling considerable distances over open country or over sea. It reproduces vegetatively by means of extremely active underground rhizomes. Even a small portion of the rhizome is capable of producing a complete plant. The underground rhizomes enable it to withstand fierce fires, and after burning, the grass sprouts quickly again producing fresh shoots. In fact fire favours the growth of this grass.

It has an adverse effect on growth of many economic crops. Spreads more rapidly to the extinction of other plants, quickly becomes dominant and once established is very difficult to remove.

Imperata is capable of withstanding great variations in temperature. It is plentiful in Bengal where it ascends to 6,500 feet in the Himalayas. It is essentially a light-loving plant, grows mainly in open spaces and as an undergrowth in tropical forests where the crowns of the trees do not touch. It gradually thins out and dies when subjected to prolonged shading.

It is a very variable perennial grass, arising from a deep seated rhizome. Inflorescence a silvery white, very dense, narrow plume like panicle, easily recognized when the purple stigmas are emerging from the sides of spikelets. When in flower about April or May, the fields, roadsides and railway embankments become white with its silky heads.

The chief local use in tropical countries is thatching. As a thatch crop *Imperata* is as profitable as rice.

The young shoots are much relished by the cattle but according to its chemical analyses, it shows a nutritive value below the average.

Another use of this grass is as a raw material for paper making. For use in industry the grasses should be cut before or during flowering, because considerable lignification takes place in the plant during maturation of the seed. This in turn affects the cropping system, for grasses cut before the seed is ripe, can only reproduce vegetatively, which in time weakens the plant.

APPENDIX II

TABLE 1.—*Digestion of Imperata arundinacea (Illuk grass) by mono-sulphite process*

Experiment No.	Chemicals on air-dry grass: Na_2SO_3	Chemicals on air-dry grass: Na_2CO_3	Chemicals on air-dry grass: Total expressed as NaOH	Chemicals on air-dry grass: Ratio of liquor to raw material	Temperature	Duration of digestion	Yield of air-dry unbleached Pulp on air-dry grass	Consumption of bleaching powder (35% available chlorine) on raw material	Yield of air-dry bleached pulp on air-dry raw material	Index figure of cost	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12
	%	%	%		°C	hours	%	%	%		
1	12	3	9·9	6 : 1	170	3	56·8	20·8	48·8	0·198	Under-cooked.
2	14	3·5	11·5	6 : 1	170	3	51·1	14·6	46·9	0·189	Colour of the bleached pulp dull, unbleached pulp showed shives.
3	16	4	13·2	6 : 1	170	3	51·1	13·3	46·9	0·194	do.
4	18	4·5	14·8	6 : 1	170	3	51·1	6·0	47·8	0·155	Pulp well-cooked. Unbleached pulp showed few shives. Colour of the bleached pulp dull.

TABLE 2.—*Digestion of Imperata arundinacea (Illuk grass) by soda process "overhead" method*

Experiment No.	NaOH on air-dry grass	Concentration of digestion liquor	Temperature	Duration of digestion	Consumption of NaOH on air-dry grass	Yield of air-dry unbleached pulp on air-dry grass	Consumption of bleaching powder (35% available chlorine) on air-dry raw material	Yield of air-dry bleached pulp on air-dry raw material	Index figure of cost	REMARKS
1	2	3	4	5	6	7	8	9	10	11
	%	gms/litre	°C	hours	%	%	%	%		
1	16	40	140	3	14	44·5	5·8	40·2	0·119	Pulp well-cooked. Colour of bleached pulp fairly white.
2	15	37·5	140	3	14·2	48·4	13·1	40·6	0·158	Pulp under-cooked.

TABLE 3.—*Digestion of Imperata arundinacea*

Experiment No.	PRE-DIGESTION			DIGESTION			
	NaOH on air-dry grass	Concentration of digestion liquor	Temperature	Duration of digestion	NaOH on air-dry grass	Concentration of digestion liquor	Temperature
1	2	3	4	5	6	7	8
	%	gms/litre	°C	hours	%	gms/litre	°C
1	10	10	108	1	12	45	138
2	10	10	108	1	12	40	138
3	8	10	105	$\frac{3}{4}$	12	40	138
4	6	10	105	$\frac{3}{4}$	12	40	138

(Illuk grass) by soda poocess—" Fractional " method

Duration of digestion	Consumption of NaOH	Yield of air-dry unbleached pulp on air-dry grass	Consumption of bleaching powder (35% available chlorine) on air-dry raw material	Yield of air-dry bleached pulp on air-dry raw material	Index figure of cost	REMARKS
9	10	11	12	13	14	15
hours	%	%	%	%		
2	6·4	41·4	4·1	38·6	0·099	Pulp well-cooked. Bleached to bright shade.
1½	6·5	41·2	4·2	38·4	0·10	do.
1½	6·6	41·2	4·1	38·6	0·099	do.
1½	6·0	43·8	4·0	40·2	0·096	do.

TABLE 4.—*Physical characteristics of pulps obtained from Illuk grass*

Atmospheric conditions of testing room :
1. Temperature 70°C.
2. Relative humidity 65%.

No.	Description of Pulp sample	Beating time in Lampen Mill Minutes	Freeness (C.S.F. Tester)	Drainage time Seconds	Basis weight gms/sq. meter	Burst factor (Mullen)	Breaking length meters	Stretch %	Tear factor	Folding endurance (double-folds)
1	2	3	4	5	6	7	8	9	10	11
1	Soda (unbleached) (Serial No. 4, Table No. 3)	Nil	352	8	60·5	24·8	4028	1·6	54·1	41
2	Neutral sulphite (unbleached) (Serial No. 4, Table No. 1)	Nil	215	15	59·8	22·7	4256	1·7	50·1	28
3	Soda (unbleached) (Serial No. 4, Table No. 3)	10	211	15	60·7	29·0	5081	2·1	66·7	53
4	Neutral sulphite (unbleached) (Serial No. 4, Table No. 1)	10	151	25	60·4	26·3	5832	2·2	68·8	63
5	Soda (bleached) (Serial No. 4, Table No. 3)	Nil	251	15	60·9	27·7	4301	1·9	61·4	83
6	Neutral sulphite (bleached) (Serial No. 4, Table No. 1)	Nil	153	30	60·2	24·6	4328	2·1	64·9	36
7	Soda (bleached) (Serial No. 4, Table No. 3)	10	156	30	60·2	37·3	5556	2·0	64·6	124
8	Neutral sulphite (bleached) (Serial No. 4, Table No. 1)	10	98	41	59·8	30·5	5005	2·2	68·7	72

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART IV.—WRITING AND PRINTING PAPERS FROM *HELICTERES ISORA*, LINN. (*MAROR PHAL*)

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SUMMARY

Laboratory experiments on the production of chemical pulps from *Helicteres isora*, Linn. (*maror phal*) are described. Results of pilot plant experiments on the production of chemical pulps and writing and printing papers are included. Admixture of chemical pulps from *maror phal* with long-fibred chemical pulps such as sabai grass pulp gave writng paper with higher strength properties. It has recently been reported that the bark of *Helicteres isora* has been found suitable as a substitute for jute in the preparation of gunny bags. The wood of this species should, therefore, be available at a cheap price. Besides, there is no other use for this wood.

INTRODUCTION

The present production of writing and printing papers in paper mills in this country is not sufficient to meet our current requirements. Some of the existing paper mills have undertaken expansion programmes. Some new units are being installed. At present bamboo and sabai grass (*Eulaliopsis binata*) are mainly used for the production of paper in this country, the former to the extent of about 63% and the latter about 22%. The existing paper mills are finding it difficult to get enough of these raw materials to work to their full capacity. The need is, therefore, all the more to explore the possibilities of utilizing new cellulosic raw materials for the indigenous paper industry. The President of this Institute came across *Helicteres isora* (*maror phal*) during his recent tour of the forests in the Saharanpur Division. Since this shrub grows gregariously in these forests and is also found in forests of other States, its wood is of light cream colour and its bark is used for cordage, he suggested that this species should be tested for its suitability for paper-making. An investigation was, therefore, undertaken in this Branch on the production of chemical pulps and writing and printing papers from this species. The results of this investigation are recorded in this bulletin. Since the completion of this investigation, it has been reported that the trials carried out under the auspices of the Uttar Pradesh Forest Department have revealed that the bark of this wood is a suitable substitute for jute for the preparation of gunny bags.

DISTRIBUTION AND USES[1]

Helicteres isora, Linn., belongs to the Natural Order Sterculiaceae. It is a large shrub attaining the size of a tree, with thin spreading branches, grey bark and young parts covered with hairs. Its flowers are 1–2 inches long and are brick-red in colour. Its fruit is also 1–2 inches long; it is cylindrical and is composed of five spirally twisted carpels. In Northern India the flowers appear chiefly in July–August and the fruit ripens in December–January[2]

The shrub coppices very well, shooting up rapidly again even if cut or burnt annually. The wood of this species is light cream in colour and soft. This species is distributed in sub-Himalayan tract from Jhelum to Nepal, Bihar, Central and South India, Western Peninsula, Ceylon and probably Burma. It is also found in Java and North Australia.

Its bast fibre is strong, thin and silvery and when combed resembles jute in appearance. As stated above, it has recently been reported that its bark has been found to be a good substitute for jute for the preparation of gunny bags. Its bark is used for cordage and rough sacks. Its fruit and leaves are very frequently used in Indian medicine.

THE RAW MATERIAL

The twigs used in this investigation were supplied by the Divisional Forest Officer, Saharanpur, from Dholkhand Range. The twigs were supplied with the bark on. The supply consisted of twigs of varying lengths (3′ 3″–5′ 9″) and diameters (0·5″–3·5″). The colour of the bark was grey and of the wood light cream. The moisture content of these twigs was about 35%. The proportion by weight of the bark to the wood depended upon the size of the twig. When 20 representative samples of twigs of different diameters were taken, it was found that bark formed 24·7% of the twigs. For some experiments the wood was used after the removal of the bark and for others wood with bark was used. In the initial experiments the twigs were chipped without crushing but in all the remaining experiments the twigs were crushed between the rollers of the factory crusher and cut into chips of about 1 inch length. The fines were rejected by sieving the chipped material on the factory sieves. This chipped and sieved material was used for laboratory experiments and pilot plant trials.

CHEMICAL ANALYSIS

The wood with and without the bark was chemically analysed by the Forest Products Laboratory Methods[3] except in the case of pentosans where the TAPPI standard T 223m–48 was employed. The wood with the bark was also analysed because it was intended to use unbarked wood for the production of paper. The results of the chemical analysis are given in Table I.

TABLE I

Property	% on the oven-dry basis except moisture	
	Wood with bark	Wood without bark
1. Moisture	7·92	4·08
2. Ash	3·10	1·68
3. Cold water solubility	11·51	6·19
4. Hot water solubility	12·08	6·47
5. 1% NaOH solubility	27·84	19·15
6. 10% KOH solubility	36·82	29·10
7. Ether solubility	4·29	0·43
8. Alcohol-benzene solubility ..	9·65	5·63
9. Pentosans	11·90	16·00
10. Lignin	19·87	13·60
11. Cellulose (Cross and Bevan) ..	48·30	51·40

It will be seen from the results recorded in Table I that the bark contains larger proportions of mineral matter, water solubles, hemicelluloses, fats, resin and lignin than the wood but lower proportions of pentosans. The cellulose content of the wood is sufficiently high to warrant its utilization for the production of paper.

FIBRE DIMENSIONS

The determination of the length and diameter of the fibres of the pulps from the wood and bark of this species was carried out by the methods described earlier[4, 5]. The results are given in Table II.

TABLE II

Fibre Dimensions

	Wood without bark		Bark	
	Fibre Length mm.	Fibre Diameter mm.	Fibre Length mm.	Fibre Diameter mm.
Minimum	0·40	0·0100	0·74	0·0067
Maximum	1·34	0·0230	2·36	0·0230
Average	0·92	0·0164	1·41	0·0145

The pulp from this wood is short fibred. The average fibre length of the pulp from the wood is less than that of the pulp from the bark, but its diameter is larger.

PRODUCTION OF PULP

A number of digestions were carried out by the sulphate and soda processes. In the sulphate process a mixture of caustic soda and sodium sulphide in the ratio of 2 : 1 by weight was used. In the soda process caustic soda alone was used. When the twigs were chipped without crushing and the chips were used for digestion, it was found that the pulp contained some shieves due to the knots not being cooked. Hence in all subsequent experiments the twigs were crushed between the rollers of the factory crusher and then chipped. Most of the digestions were carried out without the removal of the bark from the twigs. In some experiments bark was removed from the twigs and the debarked material was used for digestion. It was noticed that it was easier to remove the bark from the twigs after crushing than before crushing.

In the sulphate process digestions were carried out using 20–23% chemicals (on the weight of air-dry raw material) at temperatures ranging from 148° to 170°C. The digestions were carried out for 6 hours in all cases excepting in the case of the digestion at 170°C where the period of cooking was restricted to only 4 hours. More than 23% chemicals were not tried because higher quantities of chemicals were found to yield pulps of lower strength properties. Two digestions were carried out by the sulphate process using the two-stage ('fractional')[6] method of digestion in order to see whether any special advantages were obtained by this method. The results of all these experiments are recorded in Table III.

Since *Helicteres isora* is found in Saharanpur Division and since paper mills in Uttar Pradesh and Punjab use the soda process for digestion, some experiments were also carried out using the soda process. The digestions were carried out using 20–24% caustic soda (on the weight of air-dry raw material) at 153–162°C for 6 hours. The results of these experiments are recorded in Table IV.

DISCUSSION

It will be seen from the results recorded in Table III that easy-bleaching chemical pulps with satisfactory strength properties can be prepared from *Helicteres isora* by the sulphate process. When the one-stage ('over-head')[6] method of digestion is used, conditions given in Serial Nos. 6 and 10 are the most suitable for getting pulps with satisfactory strength properties. On comparing the results of Serial No. 5 with those of Serial No. 4, it will be seen that higher quantities of chemicals yield pulps with lower strength properties. On comparison of the results of Serial No. 6 with those of Serial No. 7 and of Serial No. 9 with those of Serial No. 11, it will be seen that pulps in lower yields and lower strength properties are obtained if higher temperatures are used for digestion. By crushing the twigs before chipping pulps free from shives are obtained. This is due to the better penetration of the cooking liquor into the knotty portions in the crushed material. Although the results recorded in Table III indicate that pulps with slightly better strength properties are obtained when the twigs are used without the bark (cf. Serial Nos. 9 and 10 and Serial Nos. 11 and 12), pilot plant experiments have shown that there is no appreciable difference in strength properties of pulps from the unbarked and debarked material.

When the two-stage method of digestion is used, whiter pulps in slightly better yields are obtained. Strength properties of pulps are also generally better in this method of digestion than when the overhead method is used.

It will be seen from the results recorded in Table IV that chemical pulps with strength properties suitable for writing and printing papers can also be prepared from *Helicteres isora* by the soda process. Under the conditions studied, the digestion conditions of Serial No. 2 are the most suitable by the soda process. Compared to the sulphate process, this process gives slightly greater yields of bleached pulps but the bleach consumption is more.

PILOT PLANT TRIALS

In order to confirm the results of the laboratory experiments regarding the suitability of *Helicteres isora* for the production of pulps for writing and printing papers, three large scale experiments were carried out on the pilot plant of this Branch. In each case about 1,000 lb. of air-dry crushed chips were used. The overhead sulphate process was used in each case using 22% chemicals (on the basis of the air-dry raw material) in 5·5% concentration for 6 hours. In two experiments the material was digested at 162°C for the first 2 hours and 153°C for the remaining period whereas in the third experiment the higher temperature of 162°C was used for the first 1 hour only. The pulps were bleached with bleaching powder in two stages. In the first stage of bleaching about 66% bleaching powder required for the complete bleaching was used and the bleaching was carried out at 35°C. After this the pulp was washed and treated with 2% caustic soda on the weight of the pulp at 70°C for 1½ hours. This was followed by cold bleach with more bleaching powder. The pulp was finally washed with water.

Printing and writing papers were made from these pulps on the Fourdrinier machine. This machine has a deckle of 34″ and can be worked at a maximum speed of 50 feet per minute. The paper machine was worked at its maximum speed. Requisite quantities of rosin size,

alum and China clay were added to the stock before it was used for making paper. In two experiments printing papers were made with a furnish consisting of only *Helicteres isora* pulp. Since pulps from this species are short fibred, 40% of sabai grass pulp was mixed with 60% of *maror phal* pulp in the third experiment. In this case writing paper was made. The pulp yields and the bleach consumption of the pilot plant experiments are given in Table V and the strength properties of the writing and printing papers in Table VI. The Serial Nos. in Table VI correspond to those in Table V. Two samples each of printing and writing papers are attached at the end of this bulletin. The printing paper made from *Helicteres isora* was used for printing the June 1951 issue of the *Indian Forester*.

From the results given in Table V it will be seen that easy-bleaching pulps in 35–36% yield can be prepared on a large scale from unbarked and barked *Helicteres isora*. The results recorded in Table VI show that it is advantageous to mix *Helicteres isora* pulp with long-fibred pulp such as that of sabai grass. Not only are the strength properties of resultant papers improved by such admixture but also the papers run better on the machine. Observations made during the production of paper on the pilot plant from *Helicteres isora* pulps have shown that it is essential to admix these pulps with 30–40% long-fibred pulps such as those of sabai grass or bamboo if successful runs without breakages are to be made at 300 feet per minute which is the usual speed at which writing and printing papers are made in the industry.

From the results of the pilot plant experiments it is clear that writing and printing paper of satisfactory strength properties can be prepared by admixing about 40% of sabai grass or bamboo pulp with *maror phal* pulp. *Helicteres isora* should be available at a cheap price since its bark is useful for cordage and as a substitute for jute in the preparation of gunny bags and the wood is not used for any special work at present. Since this species is available in Uttar Pradesh, Bihar and Orissa, paper mills in these States can use the wood of this species to supplement the fibrous raw materials they are using at present. Since this raw material should be available at a cheap price, its use by paper mills as an additional raw material will be helpful in reducing the cost of production of paper.

CONCLUSIONS

1. Twigs of *Helicteres isora* yield well cooked pulps free from shives if these are crushed before chipping.

2. For preparing well cooked pulps suitable for writing and printing papers from *Helicteres isora* the material can be used with or without the bark.

3. Chemical pulps can be prepared from this species by the sulphate or the soda process. Soda pulps consume more bleaching powder than sulphate pulps to attain the same degree of whiteness.

4. For small scale digestions chemicals more than 22% on the basis of the raw material and temperatures higher than 153°C yield pulps with lower strength properties. For digestion on a large scale, it is advantageous to use for the first 1 or 2 hours a higher temperature of 162°C.

5. Since chemical pulps from this species are short-fibred, it is essential to admix these pulps with about 40% of long fibred pulps such as those of sabai grass or bamboo to produce writing and printing papers of satisfactory strength properties.

6. Paper mills in this country should find it advantageous to use *Helicteres isora* as a supplementary raw material as this should be available at a cheap price.

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TABLE III.—*Sulphate digestions of Helicteres isora*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : Na_2S=2:1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder, i.e., 35% available chlorine*	Bleached pulp yield*
	%	gms./litre	°C	hours	%	%	%	%
1	20	50	162° for the first 3 hours, and 153° for the remaining period	6	19·4	44·4	7·9	40·6
2	20	50	162°	6	19·7	44·4	7·9	38·1
3	20	50	170°	4	19·2	40·0	7·9	35·6
4	21	52·5	162° for the first 3 hours, and 153° for the remaining period	6	19·1	40·4	7·9	34·0
5	23	57·5	,,	6	20·6	37·2	8·6	33·6
6	20	50	153°	6	18·1	41·6	6·5	35·2
7	20	50	162° for the first 3 hours, and 153° for the remaining period	6	18·0	41·6	6·4	33·3
8	22	55	148°	6	17·5	41·6	7·1	35·2
9	22	55	153°	6	19·9	39·5	6·5	35·1
10	22	55	153°	6	19·1	42·7	7·3	34·2
11	22	55	162°	6	19·5	41·1	7·2	33·1
12	22	55	162°	6	19·2	42·7	7·2	36·1
13	8 in the first stage and 15 in the second stage	20 in the first stage and 37·5 in the second stage	110° in the first stage and 153° in the second stage	2 in the first stage and 3 in the second stage	20·0	40·3	7·2	36·2
14	10 in the first stage and 15 in the second stage	25 in the first stage and 37·5 in the second stage	,,	,,	20·5	38·7	6·0	36·2

* The % is expressed on the basis of the raw material (air-dry).

and strength properties of standard sheets

Strength Properties of Standard Sheets Conditioned at 65% R.H and 70°F							
10	11	12	13	14	15	16	17
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper)	Remarks
c.c. (C.S.F.)	gms./sq. metre	metres	%			double folds	
313	62·5	6222	3·3	100·0	42·9	470	In Serial Nos. 1–5 the raw material was chipped without crushing and used with the bark. Some shives were present.
414	58·8	6430	3·6	87·0	38·9	120	
373	67·3	5253	4·8	73·8	33·8	90	
323	58·4	5745	3·8	71·1	32·6	70	
343	61·3	4613	2·6	46·9	23·6	10	
284	61·5	6993	4·3	98·7	44·6	590	In Serial Nos. 6–9 the twigs were chipped after crushing and used with bark.
245	60·1	4992	3·7	68·8	31·0	50	
280	61·8	5522	4·2	77·7	33·4	70	The pulp was yellowish.
245	60·7	5710	4·4	64·9	33·7	50	
307	62·2	7405	3·8	85·2	41·3	180	The twigs were chipped after crushing and used without bark.
224	64·5	5583	3·0	58·3	28·7	30	The twigs were chipped after crushing and used with bark.
337	60·6	6753	3·6	74·4	41·0	120	The twigs were chipped after crushing and used without bark.
272	62·0	6648	4·6	98·5	45·1	580	"Fractional" method of digestion was employed using chips of crushed twigs with bark. Only NaOH was used in the first stage of digestion. Whiter pulp was obtained than in the case of the "overhead" method.
277	62·3	6265	4·1	89·5	39·1	150	

TABLE IV—*Soda digestions of Helicteres isora*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total alkali as NaOH*	Concentration of alkali as NaOH	Digestion temperature	Digestion period	Alkali consumption as NaOH*	Unbleached pulp yield*	Bleach consumption*	Bleached pulp yield*
	%	gms./litre	°C	hours	%	%	%	%
1	20	50	153°	6	17·5	43·5	10·9	38·6
2	22	55	153°	6	16·8	43·5	8·7	38·6
3	24	60	153°	6	14·9	38·6	9·7	34·6
4	24	60	162°	6	15·3	36·8	9·7	34·7

* The % is expressed on the basis of the raw material (air-dry).

TABLE V—PILOT

Sulphate digestions of Helicteres

1	2	3	4	5	6
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*
	%	gms./litre	°C	hours	%
1	22	55	162° for the first 2 hours and 153° for the remaining period	6	18·3
2	22	55	,,	6	16·7
3	22	55	162° for the first 1 hour and 153° for the remaining period	6	—

* The % is expressed on the basis of the raw material (air-dry).

and strength properties of standard sheets

Strength Properties of Standard Sheets Conditioned at 65% R.H. and 70°F							
10	11	12	13	14	15	16	17.
Freeness of pulp	Basis weight	Breaking length	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding resistance (Schopper)	REMARKS
c.c. (C.S.F.)	gms./sq. metre	metres	%			double folds	
238	64·1	6377	4·1	80·7	40·7	190	In all the four experiments the twigs were crushed and cut and used with the bark. Pulp was not quite white in Serial No. 1.
238	63·7	6383	4·1	79·2	43·6	160	Pulp was good and white.
249	62·8	5109	4·0	65·8	33·3	50	,, ,, ,,
238	63·7	4542	3·5	56·4	28·4	20	,, ,, ,,

PLANT TRIALS

isora and pulp yields

7	8	9	10
Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*	REMARKS
%	%	%	
40·8	7·3	34·9	Stems with the bark were crushed, cut and sieved on the factory sieves. Well cooked pulp was obtained.
44·7	7·4	36·3	Stems without the bark were used. These were crushed, cut, etc., as in Serial No. 1. Well cooked pulp was obtained.
—	—	—	Stems with the bark were used as in Serial No. 1. Well cooked pulp was obtained.

TABLE VI—PILOT

Strength properties of papers produced from Helicteres isora pulps described in Table V. at 65% R.H.

1	2	3	4	5	6	7		8		9	
Serial No.	Freeness	Ream weight	Basis weight*	Thickness	Bulk*	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	$17\frac{1}{2}'' \times 22\frac{1}{2}''$ —500 lb.	gms./sq. metre	mils.		Kilograms breaking strain for 1 cm. width		metres		%	
						Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
1	131	18·4	61·6	3·35	1·22	1·61	1·08	2600	1760	1·6	3·6
2	188	17·2	60·7	3·95	1·49	1·81	0·884	2980	1460	1·6	2·7
3	133	19·0	64·5	3·6	1·42	2·90	1·33	4500	2060	2·0	4·9

* For calculating this, oven-dry weight of the paper was used.

PLANT TRIALS

Serial Nos. in this table correspond to the Serial Nos. in Table V. The papers were conditioned and 84° F

10		11		12	13	14		15
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding resistance (Schopper)		REMARKS
gms.				lb./sq. inch		double folds		
Machine direc-tion	Cross direc-tion	Machine direc-tion	Cross direc-tion			Machine direc-tion	Cross direc-tion	
17	19	28·2	30·8	10·5	11·9	3	3	Printing paper.
22	24	36·2	39·5	10·8	12·5	3	2	Printing paper.
34	38	52·7	58·9	18·4	20·0	16	11	Writing paper. This was made by mixing 60% *maror phal* pulp from Serial No. 3, Table V with 40% sabai grass bleached pulp.

SIKKIM—THE COUNTRY AND ITS FORESTS

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SUMMARY

Sikkim is an inconspicuous place in the map, and is the smallest of our neighbours. Though a very small state in area, it is perhaps one of the richest places in the Eastern Himalayas in both vegetable and animal life. Rhododendrons, Primulas, Potentilas and orchids are the real glory of Sikkim. The Avi-fauna and butterfly have got a long range in numbers. The country is picturesque and there are any number of snow-fields and glaciers and lakes to trek about. It is a veritable naturalist's paradise. Among its flora are genera that are only to be found in America, Europe, Japan, Siberia, and even in the Arctic. It is quite interesting from the anthropological standpoint too.

SITUATION AND PHYSICAL FEATURES

Sikkim, a small state adjoining North Bengal, is now a protectorate of the Government of India by the treaty of 1950. It enjoys internal autonomy and the Government of India is responsible for the maintenance of communications and defence. The area is roughly 3,000 sq. miles, and is inhabited by about 1,35,000 people. The country is more or less a wedge, enclosed by the two mighty spurs—viz., Singelila and Chola ranges, thrown out from Dongkya on the main Himalayan axis. The Singelila range separates it from Nepal in the west and to some extent from Tibet on the north and the Chola ranges separate it from Bhutan and Tibet in the east, while the rivers Rangeet and Rangpo mark the boundary in the south, dividing it from the district of Darjeeling in West Bengal. The entire state comprises the catchment area of the River Teesta. The average height of both the Singelila and Chola ridges are very high—something like 14,000′. Most of the passes across these (and there are quite a number) are above 14,000′ and some even go as high as 20,000′. There are any number of peaks above 20,000′, while those over 23,000′ are more than a dozen and half in number. The elevation of the country varies from about 700′, where Teesta leaves the State at the southern boundary, while the highest point is the top of Kanchenjunga itself (28,150′), situated on the common boundary of Nepal and Sikkim.

Besides these two main ridges, there are two intermediary ridges, which are also prominent features of the country. One of these is a subsidiary ridge of Singelila, shooting out from Kanchenjunga and terminating at the southern point (Tendong) at the confluence of the rivers Rangeet and Teesta, and at the same time dividing their catchment areas. The other shoots out from Kanchenjhau on the north and terminates at Chungthang, at the confluence of Lachen and Lachung rivers, and also dividing their catchment areas.

Those four mountain ranges are, broadly speaking in a north–south alignment. There are, however, innumerable ramifications from these, running more or less in the east–west directions, and covering the entire country. In fact, the entire area of Sikkim alternates with ridges and valleys and there is hardly any flat land in the entire country. The general run of the main river system (Teesta, Lachen, Lachung) is north–south. The entire state is covered with steep hills and deep valleys down which dash the glacial streams and torrents of water, precipitated by the excessive rainfall of this, the rainiest section of the Himalayas. Tortuous rivers cut the entire face of the country and the chief affluents of Teesta are : Rangpo, Lachen,

Lachung, Tolung, Singtam, Zemu, Dikchu and Rangeet. The gorges of Teesta and most of its tributaries are really incredible. The hills quite often, sweep down from an elevation of 16,000′ and above, to the bottom of valleys at an elevation of 3–4000′, within a distance of 7–8 miles, and supporting different kinds of flora, starting from Tropical ficus and ferns and ending in Arctic lichens, thereby making the study of the distribution of species immensely interesting. Considering the very large number of genera of plants concentrated in this small place and the exhibition among others, of some common genera of America, Europe, Siberia, Malay, Japan, and even the Arctic, the flora of Sikkim, with some four thousand and odd population, can be highly interesting to those who wish to study the inter-continental distribution of genera.

ROCK AND SOIL

For the higher peaks in the central zone and the areas near the Himalayan axis, the underlying rock is granite. From the south of this zone, the usual rock is Sikkim gneiss. Towards the southern parts of the state the Dalings with highly micaceous schists predominate, along with phyllites. At the boundary between this and the gneissic rock, they pass into silvery mica schists, with the transformation so gradual sometimes, that it is very difficult to say where one group begins and the other ends. Igneous rocks are rare in the southern half, although granite bands of intrusive origin are some times met with. The Dalings, however, have suffered considerable disturbances. The slates and phyllites frequently exhibit crumbling and contortion. The geology of the north is rather unexplored. The junction of the granite system of the Himalayas with calciferous rocks of the Tibetan plateau should be a quite interesting study. There are not many minerals either. Some copper ores of medium quality occur in the Dalings. There are also some places where graphites are noticed. Lime is rare. Quite a number of hot-springs exist in the Teesta and Rangeet valleys. The waters exhibit traces of sulphur. Soils vary from plastic and shallow—brown clay to dark-grey, porous, rich and deep type.

CLIMATE

Although the area of the State is not extensive, due to sudden changes of elevation, aspect and rainfall, the climate is different in different places. Usually, the eastern and southern portion gets a heavier rainfall (120″–150″) and locally it goes up to 200 inches in places. The western part has got smaller rainfall (80″–100″) whereas the Lachen–Lachung valley gets a rainfall varying from 40″–60″. The temperature of course, varies with elevation, but for the same elevation areas on the North are colder, due to the proximity of snows and glaciers and the presence of strong winds. The permanent snow-line in Sikkim is somewhere near 16,000′ and the glaciers are known to drop down to 14,000′ or so. There are quite a number of small lakes all along, at higher elevations (13,000′ and up), on the Chola Singelila and the Great Himalayan ranges. Most of these are thought by experts to have been formed by the recession of glaciers, along with the blocking action of terminal moraines.

THE PEOPLE

The indigenous people are the typical Himalayan Mongoloids. The eastern and southern parts of the State are inhabited by the Nepalese, who form the chief agricultural class and constitute the majority of the population. Their number will be some 70,000 as against 1,35,000 of the entire state. In the centre and along the northern borders live the Sikkimese and the Bhoteas Bhotea is a Tibetan (and people of Bhutan are known as Dukpa) and a Sikkimese is a Bhotea domiciled in Sikkim. The language of Sikkimese, though it varies a little from Tibetan, is of the same stock and so are their manners and custom. The Sherpas are another tribe, who are Buddhists like Tibetans or Sikkimese, and also wear same type of dress, but their language and custom are different. They live on the higher elevations on west, and cattle

grazing and potato cultivation seem to be their chief pursuits. The Lepchas who are the original children of the soil, are now in a minority, comprising some 20,000 in number. They are a very simple folk, prone to take things easy and are, therefore, finding themselves sandwiched between the hardy Nepalese and the portly Bhoteas. The Lepchas are mild, small in stature and simple like children. Formerly the Lepchas used to make their bags and clothes from the lasting nettle fibres, but the art appears to be dying out fast, they are now adopting Tibetan dress and custom. Lepchas, until quite recently, were animists but now quite a lot of them are Buddhists and some have turned Christians too.

In a way, the Lepchas are looked down upon by all other tribes, who do not intermarry with them. Therefore, being a small community the race is dying out slowly. The Lepchas have their own language and their vocabulary provides specific and reliable names for not only a large numbers of plants and birds, but also of butterflies. In short they are born naturalists. Lepchas alone, can make the cane bridges which are the only available means of crossing the torrents which are so abundant in Sikkim. They do grow quite a lot of cardamoms but are spendthrifts, so long any money is left. Thus, when all the other tribes are trying to take advantage of the existing high prices and wages to better their lots, it is only the Lepchas who seem to doubt whether life is worth living under the shadow of advancing civilization and probably there can be no doubt that this interesting and otherwise attractive race will soon go down the way of Forests, which they believe to be their original home ! The Lepchas avoid congestion and their huts can be seen perched on steep slopes at long intervals.

CULTIVATION AND PRODUCE

The chief articles of commercial importance are : oranges, cardamoms, and also potatoes. It is estimated that annually some 20,000 mds. of both potato and cardamoms and about 1,00,000 boxes of oranges, are exported to India. It is a deficit area in food and some 300–400 tons of rice have to be imported annually from India. It is, however, surplus in maize. In the higher hills (above 8,000′ and up to 12,000′ in summer, and below 6,000′ in winter) buckwheat and potato are grown. Potato is also grown at the lower elevations. Orange and cardamoms grow more or less in the same zone and thrive well between 1,500′ to 4,000′, and the latter grows even at 6,500′. Barley also is grown in elevations up to 9,000′. In the north, where rainfall is less, English apples (grafted to root stock of wild Pyrus) are doing well. Quite a lot of these are exported to India. Peaches, plums and pears have been quite a success though they have not been grown on a large scale like the apple. Rice is grown in valleys and even up to 5,000′, where facilities for irrigation exist. Maize is grown at all elevations up to 7,000′ or more.

THE INCIDENCE OF FORESTS

So far as the areas of forest are concerned, the percentage of forest areas to the agricultural and inhabited lands are fairly high. In fact this ratio is higher than for any province in India. But all the same the towns and villages suffer from scarcity of timber and fire-wood. The reasons for this anachronism are not far to seek—forests from all accessible and cultivable areas were cleared off due to the pressure of population. So forests exist now, as they existed anywhere in India, prior to reservation, only because people did not cut them down as they were not of any immediate benefit to them. As a result, all the valleys, roughly up to 6,000′ or so were depleted completely. The limiting factor in this case was the elevation where cereals would grow. The bulk of the existing forests—and most of it is virgin forest—is above this zone. The destruction of forests could have been heavier but for the fact that the Lepchas—the children of the soil originally, were not an agricultural community. Of course now jhuming is practised on a limited scale by almost all the tribes, but this is outside the reserved forests.

Also, there are some forests in the lower valleys (700′–3,000′), and these came to stay primarily because the places are unhealthy and, therefore, not conducive to colonization. Over-felling of big timber trees and heavy removal of fire-wood species are common features of these forests. The jhum areas are the once-depleted forests where they practise dry cultivation on a rotation of 3–5 years, depending upon the density of the population in the zone concerned. In the areas cleared of the original forests, almost fifty per cent constitute temporary cultivation and barren or scrubby waste. Extensive landslips are a common sight in these areas.

The present extent of forests may be summarized as follows : Out of the total area of the 2,870 sq. miles of the state, about 1,600 sq. miles are covered with perpetual snow (or at least covered with snow for 8 months in the year) or are rocky, and are devoid of any vegetation. Of the remaining 1,270 sq. miles of area or so, the colonized zone comprise something like 500 sq. miles. Of the remaining 770 sq. miles, about 750 sq. miles constitute the Upper Hill Forests, extending from 6,000′ to about 14,000′, and are usually virgin and inaccessible. With ropeways and other improved means of communication, about 50 sq. miles of these forests may be worked. The lower valley forests amounting to some 15–20,000 acres, are merely scattered pieces, small and depleted, but are perhaps the most valuable ones, economically.

FOREST TYPES

In common with other tropical hill forests of India the factors influencing the vegetation and forest type are, in order of importance, elevation, aspect, geological formation and rainfall. More than half of the state being covered with snow for the greater part of the year, proximity of snow is yet another important factor. Besides the variable nature of the above factors (and such incidences are only too numerous), the local position of high ridges and humidity, etc., combine to give an amazing number of mixtures of different types all through. To give a few examples, the following instances may be cited : In the adjacent district of Darjeeling, *Rhododendron arboreum*, or *R. dalhousiae* is not to be seen below 6,000′. In Sikkim the former forms pure forests even below 4,000′ and the latter is quite common near about 5,000′. Walnut like-wise descends to as low an elevation as 1,500′, where as the same occurs at 5–6,000′ in Darjeeling. *Tsuga Brunoniana* though it occurs in Darjeeling at elevations of 10,000′ or thereabouts, in Sikkim the instances are not rare when they can be seen even at 7,500′. Another interesting phenomenon that is fairly common throughout, is the abrupt sloping down of hills, from the permanent snow-line, right to the bottom of valleys (3–4,000′), in a clean sweep, in the course of 8–10 miles, giving thereby a panaromic representation of a large number of species, starting from the tropical ficus, ferns and balsams and ending in Arctic lichens, with all possible combinations of the intermediate types in between. For purposes of description, the forests may be divided into 5 zones of vegetation, chiefly according to elevation :

I.	Lower hill forests	From	700′	to	3,500′
II.	Middle hill forests	,,	2,500′	,,	5,500′
III.	Upper hill forests	,,	5,000′	,,	9,000′
IV.	Conifer forests	,,	8,500′	,,	13,000′
V.	Rhododendron forests	,,	9,000′	,,	14,000′

I. THE LOWER HILL FORESTS

There are some 3 types represented in these forests :

(*a*) Sal forests	..	Champion's Type	3b/C2-DIa
(*b*) Dry mixed forests	..	do.	3b/E-6
(*c*) Wet mixed forests	..	do.	3b/2S-4

The Sal occurs gregariously, in lower Rangeet, Teesta and Rangpo valleys, up to an elevation of about 2,500′ or so and usually on the eastern and southern aspects. On the opposite sides of these Sal forests in Teesta and Rangeet valleys, in the Darjeeling district, the crop is essentially miscellaneous, merely because of the aspect. The usual associates of Sal are: *Terminalia crenulata*, *T. belerica*, *Schima wallichii*, *Adina Griffithii*; the undergrowth, among others consist of *Bœhmeria rugulosa*, *Holmskioldia sanguinea*, *Woodfordia floribunda*, *Wrightia tomentosa*, *Phoenix acaulis*, and what is of some interest, *Pieris ovalifolia*. Also, in this zone in the lower Rangeet valley there is the interesting occurrence of *Pinus longifolia* (1000′–2000′). This is comparable to Champion's type 8/C1, only that the associates are slightly different, particularly, the undergrowths.

The dry mixed types occur on ridges with occasional Sal. Other miscellaneous species are: *Odina Wodier*, *Phœbe hainesiana*, *Terminalia crenulata*, *Tetrameles nudiflora*, *Sterculia villosa* and *colorata* and occasional *Bombax malabaricum*. The wet mixed types occur chiefly on the Northern aspects. The principal species are *Eugenia*, Laurels, *Michelia*, *Schima* and towards higher limit, *Beilschmiedia spp*.

II. THE MIDDLE HILL FORESTS (Champion's Type, 7b/C1)

At higher elevations, comparatively fewer species occur. Between the elevations of 2,500′–4,000′, the common species are: *Castanopsis* (*tribuloides* and *indica*), *Schima*, *Phœbe*; above 3,000′, *Betula cylindrostachys*, *Ostodes*, *Hovenia dulcis*, *Daphniphyllum*, *Terminalia myriocarpa*, *Engelhardtia* and *Beilschmiedia* spp. are to be seen. In all the zones *Schima*, *Engelhardtia* or *Castanopsis*, according to suitability, is the predominating species, occurring in association with the rest in varying proportions.

III. THE UPPER HILL FORESTS (Champion's Type, 10b/C1)

The following are the main types:

(*a*) Laurel forests: *Machilus-Michelia* combination, with *Engelhardtia*, *Betula* (*alnoides* and in lower zones, *cylindrostachys*), *Prunus nepalensis*, *Acers* (*Campbellii* and *lævigatum*) and *Magnolias*. Other subsidiary genera are; *Symplocos*, *Ilex*, *Turpinia*, *Mahonia*, *Vaccinium*, *Rhododendrons*, *Edgeworthia* and *Daphne*.

(*b*) Oak forests: Occur with almost all the above and *Quercus lamellosa* and *Echinocarpus dasycarpus*. *Rubus*, *Strobilanthes*, etc., also appear. It is of interest to note that *Quercus semecarpifolia*, though it occurs in both the adjacent areas of Nepal and Bhutan, so far, this species has not been reported from Sikkim.

(*c*) High level Oak forests: The species in this zone mostly consist of *Q. lamellosa* and *pachyphylla*, *Acers*, *Magnolias* and *Castanopsis*. Other associated species are occasional *Taxus baccata* and *Symplocos*. *Viburnum* is a common species in the waste lands of the zone.

THE CONIFERS

Sikkim can boast of no less than nine conifers, as described below.

1. *Pinus longifolia*.—This occurs in lower valley as has been mentioned before, with Sal. The occurrence is interesting that barring this patch they do not occur anywhere in the intermediary zone of 200 miles or so, which separate the Chir zones of Eastern Nepal and Eastern Bhutan.

2. *Podocarpus neriifolia*.—This interesting tropical conifer occurs in the moist and warm valleys up to 4,000′.

3. *Tsuga Brunoniana*.—The Hemlock spruce. It is the big conifer of the Eastern Himalayas. It does not usually occur in places having rainfall of over 100".

4. *Picea morinda*.—This spruce is also of a big size, but this does not occur in the corresponding areas of the adjacent district of Darjeeling.

5. *Taxus baccata*.—This yew occurs in Sikkim more sparsely than in Darjeeling.

6. *Larix Griffithii*.—The Larch. This is the deciduous East Himalayan conifer. It occurs in association with Fir and often is seen to colonize debris and moraines. This conifer is also absent from the Darjeeling areas.

7. *Abies Webbiana*.—The fir. This does not grow to a big size like its counterparts of the Western Himalayas.

8. *Juniperus recurva*.—This occurs in association with Fir, and grows to a handsome size of 60–70 feet (12,000′) and BHG of 6–7 feet, in suitable areas. Higher up it also occurs, as in Darjeeling district, as a prostrate shrub.

9. *Juniperus Pseudo-sabina*.—The black juniper. This also occurs in association of the other Juniper, but does not occur in Darjeeling areas.

Among the exotic ones, the common are *Cupressus* (*funebris* and *torulosa*), *Cryptomeria japonica*, and *Pinus excelsa*, all of which grow well. As regards the Blue pine, the interesting point to note is that though it occurs in Nepal and immediately on the Tibet border, on the eastern slope of Chola Range, it does not occur in Sikkim, naturally.

CONIFER FORESTS

The distribution of the conifers is mostly dependent on the incidence of rainfall. Thus *Larix*, *Picea* and black juniper occur only in the north where rainfall is less. The following types are represented in this zone ;

(*a*) Eastern Oak-Hemlock. [Champion's Type, 11/C1 (c)].
This zone is between 8,000′–9,500′ and is represented by oaks, *Magnolias*, *Acers* with Hemlock in the drier protected valleys. This occupies a position intermediate between the wet and moist temperate type.

(*b*) Eastern mixed conifers. [Champion's Type, 11/C2 (c)].
Tsuga occurs with *Picea* and *Larix*. Fir starts to come towards the upper limit along with *Junipers*. *Taxus* is seen towards the lower limit. Undergrowths are mostly *Rhododendrons* and *Andromeda*. The zone is in elevations of 9,000′–11,000′.

(*c*) Eastern Oak-Fir forests. [Champion's Type, 11/C3 (c)].
This occurs in zones of 9,000′–10,000′. The forests comprise mostly of Fir (*Abies Webbiana*) *Tsuga* and oaks. *Rhododendrons*, *Berberis* and *Rosa sericea* are common.

In the same zone, two other forest types are to be seen. These are :

(*i*) Secondary Temperate scrub forests. (Champion's Type, TP/S/2). In elevations of 9,000′–10,000′ in waste lands and forests cleared by fire, the following vegetation are noticeable : *Piptanthus sikkimensis*, *Rosa sericea*, *Andromeda*, *Berberis* and *Elsholtzia*. Extensive patches of such vegetation occur in the southern part of Singelila ridges and Lachen–Lachung valleys in the North.

(*ii*) Temperate Bamboo brakes. (Champion's Type, TP/2S/4). Extensive areas of pure bamboo crop (usually, *Arundinaria aristata*) occur in both the Chola and Singelila ridges, in southern half, at elevations of 8,000′–10,000′. The bamboos flower in something like 15–20 years cycle when usually they catch fire.

RHODODENDRON FORESTS

Rhododendrons come up from 5,000′ onwards, usually. The gregarious patches, are however, more prominent, from 9,000′ to almost 14,000′. The *Rhododendrons* can rightly be termed, the glory of Sikkim. Of the world's total population of 200 odd species, 40 are to be found in Sikkim alone. They show a remarkable range of below 4,000′ (*R. arboreum*) to 16,000′, (*R. nivale*). The latter, incidentally, is the highest level representative of woody plants! In character they appear as tiny herbs (*R. nivale* is barely 2″) and whippy epiphytes, to large trees, 50–60 feet high, with leaves over 18″ long. The flower too varies from fraction of an inch to some 5 inches in length and diameter. The colour range is equally prodigious : Several shades of red, scarlet, vermillion, crimson, rose, orange, mauve, yellow cream, purple, pink and white are to be seen.

INTERESTING FLORA

Apart from the interesting occurrence of Tropic—Artic range, the other interesting aspect of the Sikkim flora is that it contains genera that are found all over the neighbouring continents. Thus the flora of Temperate zone presents a remarkable resemblance to that of Japan, in which island we have a very similar climate, both being damp and cold. *Helwingia, Aucuba, Stachyurus,* and *Enkianthus* may be cited as instances of this similarity. Comparatively dry areas of the Sub-Alpine zone of Northern Sikkim, bordering Tibet resemble that of the Western Himalayas (in generic type at least), the Alps of Europe and Western Asia, while towards the Tibetan zone it merges into the Siberian flora.

The European and North American genera are represented in Silver fir, *Larch, Juniper,* Yew, Birch, Alder, Ash, Apple, Oak, Willow, Cherry, Walnut, Hazel, Maple, Ivy, Hollies, *Andromeda,* etc. Of the bush, *Rhododendron,* Brambles, Willows, Hony-suckle, Currant, *Spiræa, Viburnum, Cotoneaster, Hippophæ,* etc. Of North American species not found in Europe are : *Buddleia, Podophyllum, Magnolia, Hydrangea, Symplocos, Trillium, Clintonia.* Of European genera, not found in North America are : *Coriaria, Hypecoum,* and various species of *Cruciferæ.* The Japanese and Chinese flora are represented by : *Aucuba, Helwingia, Eurya, Anthogonium,* etc. The Malayan flora is represented by *Magnolia, Talauma, Vaccinium, Rhododendron, Kadsura, Marlea, Coelogyne, Engelhardtia* and Laurels. *Selagineæ,* a South African genus and Arctic lichens, of *Lecidea* spp. and *Lecanora* spp. are also represented.

Other interesting plants are the Giant Rhuburb, *Rheum nobile,* handsome and growing to 6 feet. This was described by Hooker as most beautiful of herbaceous plants. Other plants that occur in large numbers are : *Scitamineæ, Acrides, Primulas,* poppies, *Potentillas,* lillies, *Saxifragas,* nettles, *Pothos,* ferns and *Pipers.* About six species of tree ferns have been found in Sikkim. In high altitudes, *Delphinium glaciale, Saussurea,* and *Nardostachys jatamansi* are available. *Ephedra gerardiana* also occurs in the northern dry areas bordering Tibet. The ephedrine content, however, has been found to be very small. Of the 4,000 odd orchids of the world Sikkim has some 450. About 20 kinds of bamboos are to be met in Sikkim—the largest being 50–60 feet high where nodes of 8″ diameter are not infrequent and the smallest growing only to a few feet with a fraction of an inch in thickness. Some bamboos look quite handsome with a pink or blue colour.

THE FAUNA

The fauna is also interesting both in number and in kind. About 500 kinds of butterflies and 1,500 kinds of moth have been collected from Sikkim. The largest butterfly has a wing expanse of 6–8″, and the largest moth—the Atlas moth—measures some 12″. There are some 5–600 species of birds available in Sikkim, with wing expanse ranging from barely 3″ to as much as 9½ feet. Other interesting animals are the cat bear, an arboreal animal looking very much like a small bear but with a long tail (*Ailurus ochraceous*) ; wild sheep (*Ovis ammon*) is seen

FIG. 1.

Fir forests,
Sherathang valley
(13000′), Chola Range.

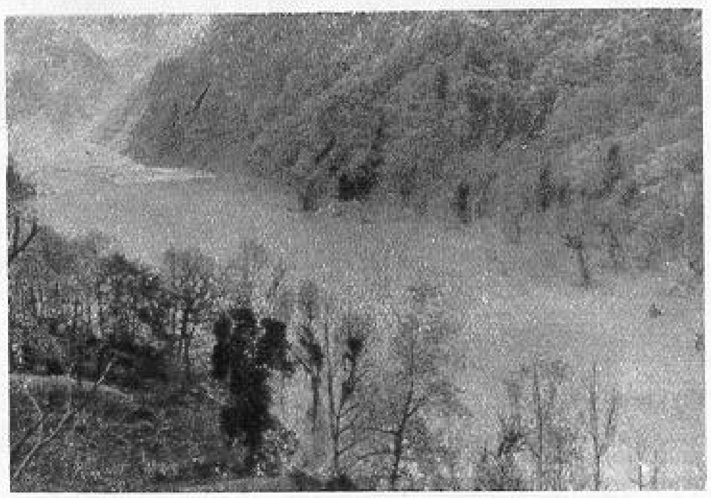


FIG. 3.—A big land slide on Teesta (Lachen stream, above Chungthang) has dammed the river to form a temporary lake.

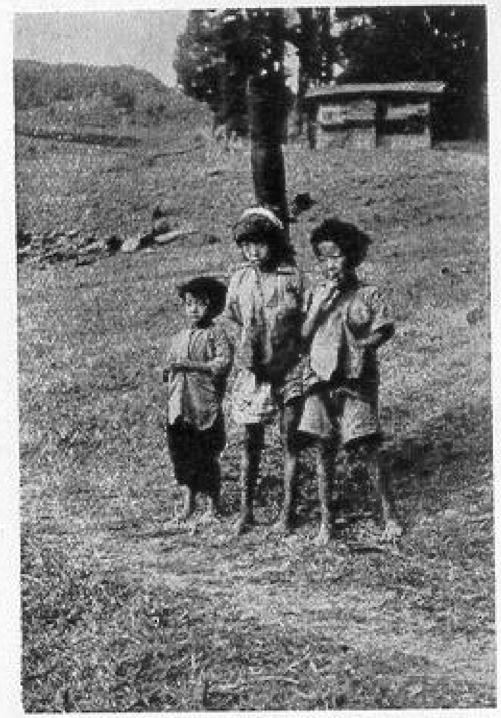


FIG. 4.—Lepcha boys carrying water. The vessels are usually made of the giant bamboo, *Dendrocalamus Sikkimensis.*

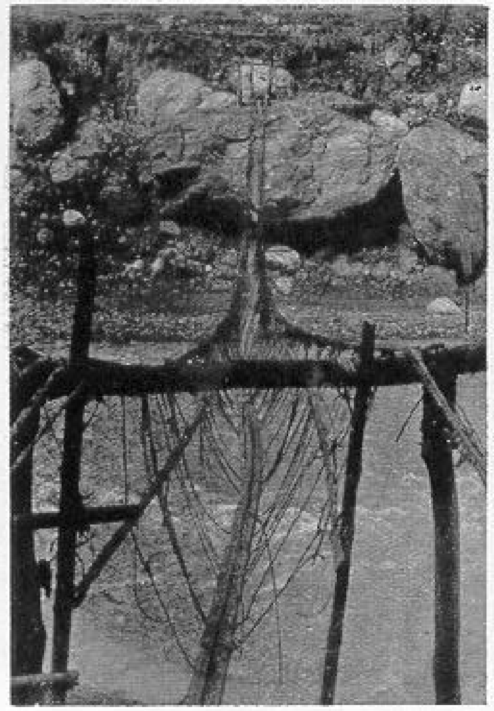


FIG. 5.—A Lepcha cane bridge over Teesta. The span is over 200 ft.

FIG. 6.—Yaks grazing in the Tsuga—Fir—*Rhododendron* forests (11500′).

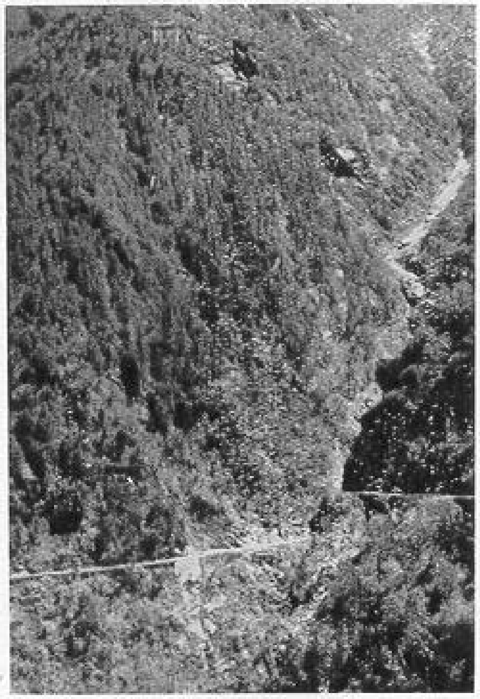


FIG. 7.—*Juniperous recurva* growing on steep hill sides (11000′–12000′).

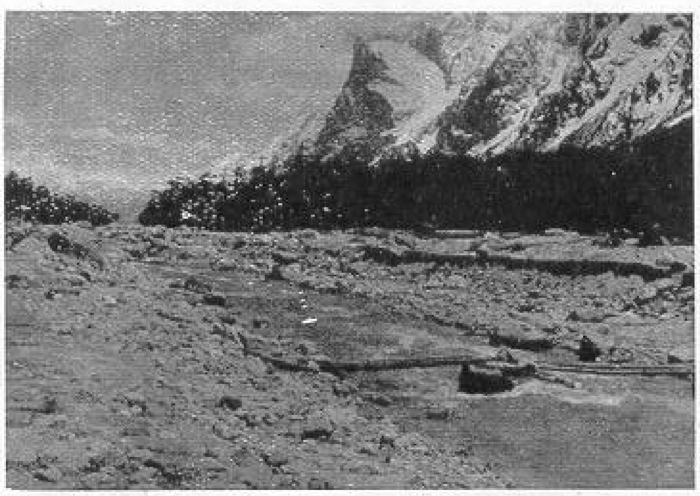
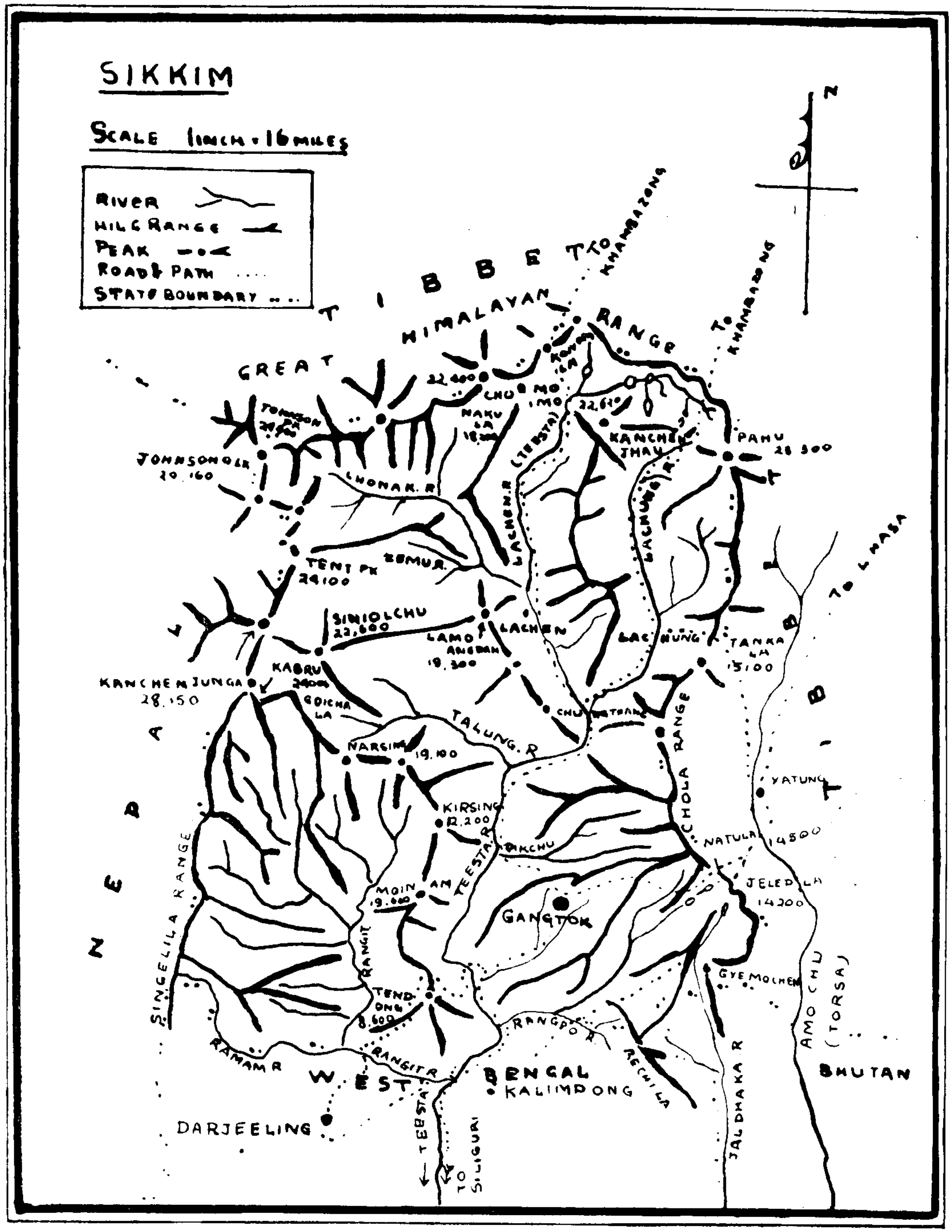


FIG. 8.—Fir forests in Lachung valley (11500′).



SIKKIM
SCALE 1 INCH = 16 MILES
RIVER
HILL RANGE
PEAK
ROAD & PATH
STATE BOUNDARY
N
TIBBET
GREAT HIMALAYAN RANGE
TO KHAMBAZONG
NEPAL
SINGELILA RANGE
KANCHENJUNGA
28,150
KABRU
TENT PK
24,100
SINIOLCHU
22,600
LACHEN
LACHUNG
PAHU
GANGTOK
NATULA
14,800
JELEP LA
14,200
YATUNG
TO LHASA
CHOLA RANGE
TEESTA R
TALUNG R
LHONAK R
ZEMU R
RANGIT
RANGIT R
RAMAM R
RANGPO R
WEST BENGAL
KALIMPONG
DARJEELING
TO SILIGURI
BHUTAN
AMO CHU (TORSA)
JALDHAKA R
GYEMOCHEN
TENDONG
8,600
MAINAM
19,000
KIRSING
NARSING
19,100
JOHNSON BLK
20,160

in the north where migratory marmots from Tibet are also to be seen. The steep hill-sides harbour a number of species of goats and antelopes. The occurrence of snow leopard and of course, musk dear, are known.

MINOR FOREST PRODUCE

Besides bamboos, the following minor products are collected by purchasers from time to time. These are: *Chireta* (*Swertia chirata*), Pepper (*Piper* spp.), *Brikh* (*Aconites*—3 or 4 spp.), *Jatamasi* (Spikenard) *Nardostachys jatamansi*, *Butch* (*Acorus calamus*), *Padamchal* (*Rheum nobile*), *Manjitha* (*Rubia cordifolia*), *Nagbel* (*Lycopodium clavatum*). There are some 5–10 varieties of cane available, which are largely used by the Lepchas particularly, Juniper twigs are used in a fairly good quantity to burn as incense in the house for rituals and in monasteries. *Digitalis* grows well, but the yield of the drug is rather low. *Kuth* was successfully introduced in the Lachung valley (elevation about 12,000′, rain fall, 40″), but is being given up on account of the big slump in the trade. Paper is also produced on a cottage industry scale, from the plants, *Daphne* and *Edgeworthia*. Lepchas weave a kind of cloth with nettle fibres, for preparing their dress, bags and fishing nets. The fibres are remarkably lasting.

DEVELOPMENT AND WORKING PLANS

The forests, so far, had no working plans, but one has now been prepared. After the Forest Department was constituted in 1907, the areas were demarcated into Khas, Gorucharan and Reserves. The people have the right for free grazing, firewood, and timber from forests other than reserves. The management so long had been dual—the local landlords were responsible for the protection and maintenance part of Forestry. Now of course, the entire State Forests are managed by the Forest Department.

The exploitation consisted so far, in removing dead and fallen trees and standing trees over a certain minimum B.H. Girth, depending upon the species. By this method, of course, all the trees in the easily accessible areas have long been exhausted. Plantations, from foot-hills to the high hills (up to 6,000′), though not unknown, are neither extensive, nor regular. Plantations have so far been raised by merely filling up the blanks in the high forest and no clear-felling as such was resorted to. Plantations of *Shorea robusta*, *Cedrela toona*, *Duabanga sonneratioides*, *Bombax malabaricum*, *Alnus nepalensis*, *Bucklandia populnea*, *Cryptomeria japonica* and *Juglans regia*, exist, on a modest scale.

The valuable forest lies in the more inaccessible areas. The hemlock, larch and junipers have been found suitable for pencil making and the two former make excellent tea-chest battens, better than fir. Spruce is also moderately good for the purpose. There are a considerable number of ply-wood species as well, like, *Michelia excelsa* and *lanuginosa*, *Bucklandia populnea*, *Schima Wallichii*, *Betula alnoides* and *cylindrostachys*, *Cedrela spp.*, *Chukrasia tabularis*, and various *Machilus* species. But the crux of the whole problem is communication, which, from the forest point of view is almost nil. The mileage of the existing motor road is very small and that too is situated far away from the main bulk of the forests. The only hope for future development of the forests of the state, lies in (*a*) the success of floating down timber by the Teesta, (*b*) Extensive use of gravity ropeways and improvement of feeder roads.

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FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

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PART II

(*Continued from* The Indian Forester, *October 1951, page 634*)

THE SUDAN

The N. and NE. parts of the Equatorial Forest cross the Sudanese boundary from French Equatorial Africa and the Belgian Congo in the region of Yambio. To reach this region from Khartoum a long trek by river steamer has to be undertaken of some fortnight or more the upper waters of the White Nile are reached, the Sudd region is reached at something over 700 miles distant from Khartoum. From here to Rijaf 1,096 miles from Khartoum and the steamer terminus, rapids barring a further progress by steamer, a forest country may be said to exist, tropical in its character. Kosti is 199 miles by river from Khartoum, about 13° latitude. It is from somewhere near to the South that what may be termed the forest lands of the Sudan as distinguished from the scrub forests commence.

The description of the scenery on the river going from Kosti to Rajaf is given here to portray to some extent the change in the forest type.

> Four miles south of Kosti the White Nile Bridge is passed. The country now changes : there is no river in cultivation. Dense forests become frequent, while on the Islands and the shores of the mainland dense patches of papyrus reed are noticed.
>
> The country of the Arabs is being left behind and that of the negroes lies before the traveller. Occasional Shilluk villages are seen on both banks and the inhabitants may often be met with in their dug-out canoes.
>
> At 246 miles, Jebelein, distinguished by its five quaint peaks, is seen on the right bank. There is a station here and a busy market, where a brisk trade is done at certain seasons.
>
> In the neighbourhood is a settlement of the Tasisha Arabs, kinsmen of the Khalifa Abdullahi, who originally came from Darfur.
>
> After this the river winds through forests, reedy islands and occasional masses of floating weed. About 45 miles south of Jebelein the southern boundary of the White Nile Province is passed and the Upper Nile Province begins.
>
> At 291 miles, Renk is reached. At 340 miles Gebel Ahmed Agha appears, a sombre looking hill about 350 feet in height. The scenery retains its character, forests and grassy swamps appearing on both sided of the river, whilst an occasional fishing village is passed, the villages of the Dinkas being several miles inland.
>
> Kaka (390 miles) is a large group of Shilluk villages and the northern limit of the Shilluk country, The inhabitants live mostly by fishing and hunting.

Some of their canoes are of very ingenious construction. The Ambach limbs taper from the roots and the natives lash a number together so as to form a handy-shaped little canoe which can easily be carried on a man's head, if necessary when hunting. When soaked they have to be dried in the sun.

Landing is difficult owing to the belt of reeds. Many Shilluk villages are seen on the left bank.

Kodok (469 miles) formerly Fashoda, is near the site of the fort constructed by Major Marchand.

About half a mile to the south is a large village, and a few miles farther on is the residence of the Mek, or king, of the Shilluks. The Shilluks are a very tall, slightly built active race, living chiefly by agriculture and fishing, and they are rather averse to manual labour. The rainy season here begins in May, and the river has a rise and fall of about three metres.

At 520 miles Malakal, the headquarters of the Upper Nile Province is passed.

Taufikia, 530 miles from Khartoum is where Baker camped for a considerable time on his return to the southern Sudan.

Four miles farther on the Sobat river, a fine stream with high banks, originating in the highlands of Abyssinia, joins the Nile. This river is navigable as far as Gambeila, in Abyssinia, during the summer, when a regular service is maintained by steamers from Khartoum. The inhabitants are Nuera and Anuaks.

Passing the mouth of the Sobat, the Nile widens considerably but the banks are very low and covered with mimosa scrub. On the East bank many Shilluk villages are seen. Grass plains extend on either bank as far as the eye can reach. Large ant hills are scattered here and there.

At 565 miles (on the right bank) the mouth of the Bahr-el-Zeraf is reached. From here the course lies through low country and trees become very scarce. Many hippo and water fowl are met with, and an occasional elephant may be seen on the right bank, possibly also lions, leopards, and very rarely giraffe.

At mile 615 Lake No is entered, and an immediate sharp turn to the south brings the steamer into the Bahr-el-Jebel, the main stream of the White Nile. This river, which has now been completely cleared of Sudd, looks like a winding canal cut through banks of papyrus for several hundred miles. Elephant and giraffe may be seen, but generally at a distance from the river bank, and the reeds, principally papyrus, tiger grass and Um Suf, stretch far on either side, making a vast uninhabitable waste of marsh.

Sudd is the name given to masses of water plants and papyrus which grow or float into the river from the neighbouring lakes. If these masses become stationary for any length of time, the roots reach the bottom and take growth.

Happily this is not at all likely to occur at the present time as since the channel was opened in 1900, the current has run with sufficient strength to keep it clear.

Steaming on through the Sudd region, lakes and lagoons border the river, and papyrus reeds seem to be the only vegetation. The bank again becomes solid at Hillet-el-Nuer (749 miles), and a few scattered Nuer villages are seen, but five miles further on the Sudd is again encountered.

At 876 miles the southern end of the Bahr-el-Zeraf branches off and the Shambe lagoon is reached at 865 miles. The village of the Kiech Dinkas and the station lie

a short distance from the river up a broad backwater, and forest land is seen. From here a road stretches across the Bahr-el-Ghazal Province through Rumbek to Wau.

The marsh lands appear much lower, and firm ground and trees are visible in the distance. The channel continues its extra-ordinary twisting, trees become more plentiful, and a wooding station is situated on the western bank. The papyrus is replaced by tiger grass and Um Suf, and grass fires occur frequently.

The scenery then changes. Many villages and cattle are seen and the vegetation becomes more typically tropical. The inhabitants are Bari negrœs, a tall and strongly built race. Their huts are well constructed, neat and picturesque. After leaving Bor the river takes a sharp turn, and some cultivated ground is passed.

Mongalla (1,055 miles) on the east bank is the capital of the province bearing that name, and is the centre of the local raingrown cotton industry, in which almost the entire population is now becoming interested.

Lado at 1,068 miles on the west bank was at one time the principal Belgian station on the Nile, and was strongly garrisoned. It was formed by Gordon in 1874, and was for a while the headquarters of Emin Pasha. It has now been abandoned.

Leaving here, the course is resumed to Gondokoro, 1,071 miles from Khartoum. The river bank is high, and fine large trees abound. Ranges of mountains are seen to the south, the river is wide, and many islands appear.

The site of Sir Samual Baker's old station, on a high bank, still shows traces of the occupation in the shape of remains of buildings, fortifications and fruit trees. At 1,087 miles is the Juba Hill Mission Station, on the west bank. This has been selected as the future terminus of the river service and the junction of the various motor roads to Kenya, Uganda and the Belgian Congo.

The steamer then proceeds through scenery of continued interest to Rejaf, 1,096 miles. A good rest-house where rooms and catering are available is established here. The traveller is now 3,019 miles from Damietta, the mouth of the Nile, over 1,500 feet above sea-level and less than 5 degrees north of the equator. Further progress by river is barred by rapids a few miles south of Rejaf. It is possible, however, to proceed by motor to either Uganda, Nairobi in Kenya Colony, or Aba in the Belgian Congo.

It has been mentioned that 13° latitude may be taken roughly as the southern limits of the creeping desert at the present time, but in the Sudan the so-called scrub forest in a varying degree stretches to the south of the line practically and roughly to El Fasher, El Obeid and the Kosti line west to east.

This is perhaps one of the most important regions in the present economy of the Sudan.

The forest lands of the Sudan have been through much the same experience as the regions to the west. There appears to be a certain difference so far as my observations go, especially to the south of El Obeid and Kosti, latitude 13° 23′ where the bush or scrub has a more virile appearance.

Starting in the west on the 13° latitude the line runs east through or close to Bignone (Gambia) Bamaco (Ivory Coast) Ouagadougou (Upper Volta now joined to the Ivory Coast) Kano (Nigeria) Maiderguri (Nigeria) Fort Lamy (French Niger). Then east to Tibesti Sand Mountains, Ennedi in French Equatorial Africa into the Sudan on to Jebel Marra, Rahad to the White Nile.

I give below information kindly afforded me by Mr. W. L. Marjoribanks, Chief Conservator of Forests, Sudan. It indicates the position from the point of view of protective values of the catchment areas of the Niles, Blue and White, and other rivers in the Sudan.

Very roughly the present position is :—

"WHITE NILE ..	I would put this enormous catchment as consisting approximately of— 5% closed forest ; 20% papyrus swamp and lakes ; 75% savannah, in which shifting cultivation is practised in varying degrees of intensity.
BLUE NILE ..	3% closed forest ; 1% lake or swamp ; and 96% savannah.
ATBARA ..	1% closed forest ; and 99% savannah, some of the latter very degraded.
RAHAD AND DINDER ..	2% closed forest ; and 98% savannah.
SOBAT, BARO AND PIBOR ..	15% closed forest ; 10% swamp of lake ; 75% savannah.
BAHR-EL-GHAZAL ..	5% swamp ; 95% savannah, mostly untroubled by shifting cultivation since slavery decimated the population of the catchment.
BAHR-EL-GEBEL AND BAHR-EL-ZERAF ..	These are merely names of two channels of the White Nile into which it divides in the Upper Nile Swamps, subsequently rejoining near Malakal".

What is going to happen to the Niles and the large populations dependent upon them ? The last big tributary of the Nile is the Atbara river which joins the Nile a few miles below Atbara in the Sudan, a distance of 1,000 miles from the Nile's mouth. In the hot weather close to Atbara itself, the water drops so that the river forms into pools with great bare and dry stretches in the bed of the river. This condition is said to be steadily increasing.

What is going to happen to rivers which have been reduced to this condition ? It is not a question of looking forward a matter of even half a century. What will be the position 500 years hence, taking into account the present position in the activities and demands of man !

Before considering the position of the Sudan some details of that historical river the Nile must be given, taken from the Sudan Almanac 1948.

> "The waters of the Nile are believed to originate in the South Atlantic. They gather from many countries :—Tanganyika, Kenya, Belgian Congo, Uganda, Ethiopia (Abyssinia). The contribution of the Sudan is negligible, that of Egypt nothing at all. Of the total volume 84 per cent comes from Ethiopia and 16 per cent from the Lake Plateau of Central Africa.
>
> *The White Nile.*—The furthest source is that of the Luvironza (6,694 kilometres from the Mediterranean Sea) joining the Kagera to enter Lake Victoria, whence the

Victoria Nile flows through Lake Kioga into Lake Albert, enters the Sudan as the Albert Nile or Bahr-el-Jebel, flows through the swamps to be joined at Lake No by the Bahr-el-Ghazal (draining the western swamps) and become the White Nile. Supplemented by the Bahr-el-Zeraf (draining the central swamp) it is joined by the Sobat (fed by the Baro from Ethiopia and the Pibar collecting the eastern swamps) and flows north to Khartoum.

The Blue Nile.—The furthest source is the Little Abbai (some 4,757 kilometres from the Mediterranean Sea) entering Lake Tana. Between Lake Tana and Khartoum, the Blue Nile is joined, in the Sudan, by the Dinder and Rahad.

The Nile starts at Khartoum, junction of the White and Blue Niles (3,021 kilometres from the Mediterranean Sea) and receives its single tributary, the Atbara, while still 2,699 kilometres from the sea.

Mean Water Levels and Distances along the Nile

	Water Level metres Above Sea	Distances	
		Kilos.	*Miles*
MAIN NILE			
Rosetta-mouth	0	0	0
Aswan Dam	86*	1180	733
Wadi Halfa	117	1531	951
R. Atbara mouth	340	2699	1677
Khartoum	371	3021	1877
BLUE NILE			
R. Rahad mouth	..	3219	2000
R. Dinder mouth	..	3280	2038
Sennar Dam	406*	3379	2100
Lake Tana exit (approx.)	1840†	4590	2852
Little Abbai source (approx.)	..	4757	2956
WHITE NILE			
Jebel Auliya Dam	372*	3065	1904
Malakal	383	3832	2381
R. Sobat mouth	383	3855	2395
Juba	453	4787	2974
Lake Albert exit	620†	5180	3219
Lake Victoria, Ripon Falls	1130†	5611	3487
Luvironza source (approx.)	..	6694	4159

All water levels are during the low season.
* At dams, water levels are downstream river level.
† Lake levels are approximate, above M.S.L. Alexandria.

Range of River Levels at Representative Stations

	Normal Year			Extreme River Gauges		
	Lowest Level	Highest Level	Range metres	Lowest	Highest	Period
Atbara .. .. (Main Nile)	May	Early Sept.	6	9·42 23/25 May 1922	16·52 27/28 Aug. 1946	1907–1946
Khartoum ..	May	Early Sept.	5½	9·21 20 May 1922	17·14 2 Sept. 1946	1899–1946
Khashm-el-Girba .. (River Atbara)	(dry)	Aug.	5½	(dry)	17·80 13 Aug. 1916	1903–1946
Juba .. .. (Bahr-el-Jebel)	Mar.	Sept.	0·60	13·36 12–20 April 1945	15·45 11 Aug. 1942	1925–1946
Roseires .. (Blue Nile)	April	Aug.	8	10·53 22 May 1914	22·68 24 Aug. 1946	1903–1946
Rabak .. .. (White Nile)	April	Sept.	2½	9·27 13 May 1922	14·08* 6 Jan. 1945	1906–1946
Malakal .. (White Nile)	April	Oct. and Nov.	2¼	9·16 15 April 1922	13·35 11–15 Mar. 1918	1905–1946

* Now influenced by Jebel Auliya reservoir.

The Nile Flood.—There are two seasons, the flood, and the rest. The flow in the Nile at the peak of the flood (late August and early September) is 16 times that of its lowest stage, in April. Just over half the total volume for the year passes in the 2½ months mid-July to September. Four-fifths passes in the 5½ months mid-July to December : this is the period of surplus when large volumes pass to the sea. The other 6½ months, January to mid-July, is the period of shortage : the volume, a fifth of the annual total, is insufficient for irrigation : the mouths of the Nile are closed by banks and no water is allowed to pass to the sea. Flood water is called "untimely" for it cannot all be used : water in the period of shortage is called "timely" for it (and much more) can all be used. Flood water takes about two weeks to Aswan and about three weeks to Cairo from Khartoum.

Contribution to Main Nile Flow

	High Flood	Low River
	%	%
From the Blue Nile	68	17
,, ,, White Nile	10	83
,, ,, River Atbara	22	..

During the flood the Blue Nile discharge may rise to 60 times that at low river, over a period : on spates it may be 300–400 times as much. It normally begins to feel the effect of the rains on the Ethiopian plateau about the middle of May and starts to rise, bringing the first red silt down to Khartoum about 20th June. The rise continues irregularly to a peak, at Khartoum, about the end of August. Late on in September it begins to fall rapidly. All the flood water is drawn from Ethiopia, about 10 per cent of the total via the Rahad and Dinder rivers (which later dry up to a series of pools). Only about 7 per cent of the discharge comes from Lake Tana.

Compared with the Blue Nile, the White Nile is much more steady, the discharge during flood being about 3 times that of the low season, rising to 5–6 times during spates. At the height of the Blue Nile flood the White Nile is ponded back above the junction of Khartoum. About half the discharge of the White Nile comes from the Sobat, which normally commences to rise towards the end of April, fed through the Baro and its tributaries from the rains on the Western Ethiopian mountains and (from about June) by water drainage from the eastern swamps through the Pibor system. The main swamp (sudd region) contribution is almost entirely from the Bahr-el-Jebel, which loses half its water on the way. The initial discharge, south of the "sudd", comes about five-sixths from the Equatorial Lakes and one-sixth from torrents joining between Lake Albert and Mongalla. The "sudd" is such a bad conductor that, broadly speaking, it contributes a volume little affected by the discharge entering it in the south, seasonal though that be.

Nile Control.—The development of the basin of the Upper Nile became the subject of intensive study immediately after the reconquest of the Sudan. The annual volume of the Nile is usually considered as the volume passing Aswan from one flood to the next, the flow having been measured through the sluices of the Aswan Dam since 1903. Records show that :

		Period
Average year	82,000 million m3	(1912–42)
Lowest year	42,000 ,,	(1913–14)
Good year	90,000 ,,	(1914–15)
Highest year	155,000 ,,	(1878–79)

The lowest year may be expected once in two centuries. For calculations engineers assume a "standard year" of 70,000 million m3 (1925–26) which is a year so low that it is safe to assume the volume will be reached on the great majority of floods. The problem of Nile control is first to even out the natural annual fluctuations of supply to agree with demand, and then to increase the standard year.

The first problem is to store untimely water from the period of surplus and release it as timely water in the period of shortage. Not all flood water can be stored, the

Blue Nile and the Atbara are too heavily laden with silt for storage (at top flood): to do so would silt up, and destroy, reservoirs. Broadly speaking, the average year gives :

One-fifth	..	timely water
One fifth	..	untimely water, not storable
Three fifths	..	untimely water, storable

Storage is at present effected in the Aswan, Sennar and Jebel Aulia reservoirs whose effective usable, capacities total about 8,000 million m3. Natural variation in annual flood makes it quite possible that, on very low years, all three reservoirs might not fill.

The first stage of the second problem is to decrease as far as possible the losses of the present flow, which really means reducing the tremendous losses in the "sudd" region. The solution now under study is to short circuit the swamps with a canal from Jonglei to the White Nile near the Sobat mouth. To get full benefit from this, a dam near Lake Albert is essential. Similarly, a dam at Lake Tana will greatly benefit the Blue Nile both by helping to reduce untimely flood water and by increasing storable and timely water.

These schemes will not of themselves sufficiently augment the standard year. The only way of further increasing the volume is by building up, in good years, a reserve at source which can be let down in poor years. This means holding a reserve in Lake Albert or in Lake Tana or in both. It is known as "over-year" storage (or century storage) as distinct from the "annual storage" of flood water in the present dams.

At present the use of the Waters of the Nile as between Egypt and the Sudan is regulated by the "Nile Waters Agreement" of 1929, which accepted the report of the International Nile Waters Commission of 1925. The Sudan may not, without prior consent of Egypt, construct works which would affect the arrival of Nile water in Egypt. Egypt may not, without first agreeing to safeguard Sudan interests, undertake conservation works. The present share of the Sudan is fixed, but guaranteed, in two ways—during the period of surplus, only by a maximum abstraction into the Gezeira Canal—during the period of shortage, by certain "free areas" under pump irrigation plus a volume (rather larger than the contents of the Sennar reservoir) for all purposes. This report and agreement are recognized as models of how such problems should be envisaged and solved, by viewing the economic use of the Nile as a whole recognizing the possibility of better solution as "Nile control" advances, and providing that in any future review all established irrigation should be respected.

The information required which is at present very meagre, if it exists at all, is the state of the catchment areas of the Blue Nile and the Atbara River in Abyssinia. The statement above given about the silt in the Blue Nile and the Atbara River *being too heavily laden* with silt for storage at top of flood are disquieting. If the obvious uncontrolled hacking and burning and overgrazing in the Blue Nile catchment areas be not controlled, how soon will this, through silt and possible floods, begin to have effects on the Gezeira cotton operations, one of the finest in the Middle East.

As to the Atbara river I wrote the following note in April 1947—"What is going to happen to the Niles and the large populations dependent upon them ? The last big tributary of the Nile is the Atbara river which joins the Nile a few miles below Atbara in the Sudan, a distance of 1,000 miles from the Nile's mouth. In the hot weather close to Atbara

itself, the water drops so that the river forms into pools with great bare and dry stretches in the bed of the river. This condition is steadily increasing. I have seen this condition from the Railway Bridge and subsequently visited the place itself. It was a disquieting site.

What is going to happen to rivers which have been reduced to this condition ? It is not a question of looking forward a matter of even half a century. What will be the position 500 years hence, taking into account the present position in the activities and demands of man" !

> "The River Atbara" says the Sudan Almanac, "contribution comes from the northern part of the Ethiopian plateau. It commences to rise towards the end of May, the flood coming down in a wave to join the Nile early in June. After the end of August it falls rapidly, and decreases to a series of pools. During the flood it is even more erratic than the Blue Nile".

NORTHERN RHODESIA

In connection with the enquiry in Northern Rhodesia the Conservator of Forests, Mr. Duff, wrote—

> "I am afraid you are asking more than we can supply. This is an immense country and part of its rivers have never been traversed. However, if you want the rough estimates of the main rivers, here they are" :—

	Length in Miles	Percentage Fringing Forest	Percentage Fringing Scrub
		%	%
Zambesi	1,660	20 +	30
Luangwa	520	30 +	10
Kabompo	310	30 +	20
Kafue	740	20 +	5
Luapula	380	20 +	20

SOUTHERN RHODESIA

In a communication received, written for the Chief Conservator of Forests of Southern Rhodesia, it is stated that

> "Few of our rivers and tributaries are perennial ; the main catchment areas are under tree veld ; the main watershed is occupied and now fairly static, and it is estimated that an average of about 73 square miles per annum are given up to crops. The total area (European and Native) under cultivation, exclusive of fallow land is estimated to be now over 4,000 square miles and more often than not this land was originally virgin forest land.

> "It is exceedingly difficult to give an indication of the area of catchment areas which have been cut over, ruined by shifting cultivation, or over grazed. Such things do happen but they are usually confined to a number of comparatively isolated patches. With increasing European supervision and direction they are gradually diminishing. In heavily populated Native Reserves fairly extensive areas devoid of trees and heavily stocked with cattle do occur, but here, too, improved forms of management are becoming more and more apparent".

"A Forest Act, now in force, will further check over-cutting".

A vegetation map of the Colony is in existence in which the main tree vegetation types are shown in broad lines.

SOUTH AFRICA

As in other cases, the Director of Forestry said—

"It has taken some time to obtain the information about the lengths of South African rivers and their tributaries".

For this latter the following tabular statement was sent. In books on travel and sport some of these names have been known, sketchily in the beginnings, for a century and more. But for others, they are probably unknown outside South Africa—which makes the following table all the more valuable.

Rivers of the Union of South Africa

River	Approx. Length (miles)	Tributary	Approx. Length (miles)
Pongola	270	Great Usutu	160
Tugela	250	Buffalo	170
		Klip	50
		Bushmans	75
		Mooi	80
Black Umbuluzi	140	..	..
Umgeni	110	..	..
Umvoti	90	..	..
Umkomaas	135	..	..
Umzimvubu	190	Tina	115
		Jsitsa	95
Umzimkulu	155	..	..
White Umfolosi	200	Black Umfolosi	100
		Mkuzi	..
Olifants (Cape)	150	Sout	140
		Doorn	160
Great Kei	..	White Kei	80
		Tsomo	110
		Black Kei	220
Gamtoos	260	Salt	130
		Kariega	120
Bashee	150	..	..
Gouritz	200	Dwyka	60
		Groote	120
Sundays	240	..	..
Great Fish	280	..	..
Great Berg	130	..	..
Breede	160	Sonderend	80
Keiskama	120	..	..

(*contd.*)

Rivers of the Union of South Africa—(concld.)

River	Approx. Length (miles)	Tributary	Approx. Length (miles)
Incomati	140	Komati	220
		Crocodile	150
		Sabi	120
		Massinonto	100
Orange	1,050	Hartebeest Sak	320
		Malopo	550
		Ongers	170
		Vaal	650
		Caledon	240
		Seacow	130
Vaal	650	Vet	165
		Sand	110
		Hartz	220
		Riet	210
		Modder	180
		Wilge	210
		Valsch	160
		Klip	90
Limpopo	750	Marico	150
		Crocodile	190
		Mogal	150
		Palala	115
		Magalakwyn	230
		Zand	150
		Pafuri	130
		Olifants	430
Olifants	440	Great Letaba	200
		Shingwedzi	160
		Steelpoort	120
		Klands	110

Dealing with c, d, e, of the questionnaire (relating to the amount of forest remaining on the catchment areas of main rivers and tributaries, that is the proportion of forest still left after lumbering, shifting cultivation, fires, etc.), the Director writes :—

> "It could be said that the area of forest is almost everywhere negligible. In the mountains many streams have forest remnants along their banks. In a true forest country these would hardly be noticed. The total area of natural forest is less than one quarter of one per cent of the Union, and the largest area lies in a narrow coastal strip between George and Humansdorp (the Knysna region) where no important rivers rise".

As is well-known South Africa has been engaged on afforestation since and before the first war. On this subject the report says—

"Afforestation with exotic species has been undertaken and plantations of Wattle (chiefly *Acacia mollissima*), Pines and Eucalyptus, including private and Government plantations, cover 1,825 square miles, which is less than half of one per cent of the total area of the Union (472,550 square miles)".

MADAGASCAR

The area of Madagascar is about 146 million acres. Of this area about 7½ million acres are dense forest with good commercial timbers, 10 million acres of average density forest, 5 million acres of scrub or savannah forest and one million acres of mangrove, rafia, etc.

The most extensive forests are on the eastern and north-western coasts of the Colony. The high plateaux formerly covered with high dense forests are denuded except for a few clumps and groves of trees in parts. In the southern and south-west part of the country only a bush vegetation with a drying up soil and water conditions now remains, evidenced in the better parts by tamarind and baobab trees.

The rainfall on the east coast is heaviest, over 100 inches per year while on the west coast it is no more than 20 inches, thus giving rise to different forest conditions in the two cases.

There can be no doubt that shifting cultivation has played an important part in the present distribution and character of the existing forest. As a result of fire, the original species of the forest, as elsewhere in the world where high forest has degenerated into 'bush', have largely disappeared. Perrier who was in Madagascar for 10 years estimated "that 95 per cent of the former species have disappeared because of fires and reckless cutting. Brush fires, together with the native method of cultivation and cutting, have destroyed three-fourths of the forests of the island and have brought about a complete change in the aspect of the vegetation. The native flora of Madagascar was arborescent, but under the action of fires it has given place to brush, which in its turn, as a result of further fires, is replaced by prairie vegetation on the plateaux and in the west, and on the east coast by ravenala, bamboo, or a brush growth resistant to fire. Destruction of the forest by the natives has gone on unchecked. When a native needs wood he selects the tree which suits him and cuts it. It frequently happens that in order to get a single tree 4 acres of forest is destroyed". A factor which many Forest Officers working in tropical countries could furnish many illustrations.

The reduction of the forest area and the condition of the remaining forests caused a Government enquiry in the early years of the present century into the effect of this forest destruction upon the climate of the island of Nossi-Be. The investigating committee reported—

"A gradual decrease in rainfall and a resulting irregularity of the seasons. The water supply has decreased so greatly as to be a matter of serious concern to the inhabitants of Helle-Ville. The same is true of Madagascar. On the plateaux the results of deforestation are apparent in extreme climatic conditions: irregular rainfall, violent winds, low temperature followed at short intervals by intense heat, and sudden freshets. The government has now adopted protective measures against further forest destruction. Brush fires for the purpose of renewing pasture land are prohibited, as well as the native method of promiscuously clearing forests for agricultural use. Some forests have been reserved along the railway ; in a number of provinces other forest

areas have been reserved. Forest management on a small scale has been attempted with fairly good results. Some re-afforestation is being done by the government. The species used in planting are chiefly Eucalyptus and Pine, Eucalyptus being the most successful. There is also a law which classifies different kinds of timber to be cut and specifies conditions on which cutting may be done".

These are good provisions but difficult of enforcement. In fact 'bush' fires, for whatever purpose they are lit, in what may be termed the shifting cultivation and pasturing of stock countries in the world requires that a common effort by all the governing powers should be undertaken to put an end to these wasteful and extermination habits ; for they threaten man and his beasts and their means of subsistence.

MAURITIUS

The island is of small size 39 × 29 miles with a superficial area of 729 square miles and a maximum elevation of approximately 3,000 ft. All the principal river systems have their sources on (1) the elevated plateau region which forms the island's main watershed 'ridge' or (2) on the more prominent subsidiary hill ranges which come from the central uplands 'ridge'. The plateau region follows a general N. to S. axis, roughly along the mid-line of the island and this fact limits the length of all the rivers and also confines their drainages to areas extending from the Coast to approximately the mid-North to South line of the island. The rainfall varies from 40″ in Northern plain to 150″ in South of the plateau.

In his reply to the questionnaire the Acting Conservator of Forests, Mr. L. F. Edgerley gives a brief history of the Colony's forests and their treatment from the time of the first Ordinance issued. It is rather typical of the way other Colonies have been from the forestry point of view, ignorantly managed.

"In 1875 and Ordinance—No. 13 of 1875—was promulgated for the specific purpose of preserving and protecting fringing forest and natural vegetation along the principal rivers, rivulets and feeders. This Ordinance was accompanied by a Schedule of Rivers, Rivulets and Feeders and laid down widths of 50′, 25′ and 10′ respectively, on both banks of each of these, which were to be called 'River Reserves'. There is, unfortunately, no record of the state of the forests included within the 'River Reserves' in 1875, and it must be presumed that some degree of cutting had already taken place, at least in the accessible areas, and particularly in the cane cultivation belts of the lowlands and coastal regions.

"At the time the Ordinance was promulgated, virtually all land in Mauritius was privately owned.

"Consequently upon an inspection report on the forests of Mauritius by an officer of the Indian Forest Service—Thompson—in 1880, and of recommendations made therein, Government proceeded to acquire, by purchase or exchange, areas of forested lands, principally in the upland regions, and roughly above the 100 ft. contour. Government now owns some 66,800 acres of Crown (Forest) Lands, the greater part of which includes the headwaters and approximately half the lengths of the principal river systems.

"One of the direct results of the acquisition of these lands by Government was to ensure more or less permanent protection of the 'River Reserves' situated above the 1,000 ft. contour. There are, of course, exceptions to this general condition, particularly in the Eastern half of the island where the gentle slope of the escarpment

has permitted the extension of sugar-cane cultivation to points above the 1,000 ft. contour.

"Local opinion suggests that up to 1908 or thereabouts virtually all existing 'River Reserves' were in good condition, though sporadic cutting of trees had, of course, taken place. It is reported that subsequent to a visit of the island, in or about, 1908 by Sir Ronald Ross, the discoverer of the origins and causitive agents of Malaria, the maintenance of the shade over rivers was thought to be a mistake and the (at least) partial clearance of 'River Reserves' within privately owned estates, principally in the lowlands, was initiated. There is no record, however, of any amendment of the provisions of Ordinance 13 of 1875, under which the cutting of any tree or vegetation within the scheduled 'River Reserves' was a punishable offence ! I have not been able to ascertain the real facts regarding this anomalous situation, but, it is quite clear that within many of the privately owned 'River Reserves' cutting and clearance of fringing forest on a large scale did take place. The result is that at the present time it is doubtful if even 5–10% of the 'River Reserves' below (roughly) the 1,000 ft. contour remain in their original form. The detailed position has never been examined and I am not able to speak in other than general terms.

"In the year 1946 fresh legislation was enacted to further protect existing 'River Reserves' as a measure to control the breeding of malaria-conveying mosquitos. This legislation seeks to maintain the maximum degree of shade over water courses, in order to inhibit, and, if possible, to prevent the growth of fresh water algæ upon which mosquito larvæ feed. The 1946 Ordinance, however, serves only to amplify the provisions of the principal Ordinance 13 of 1875—and gives to the Medical Authorities wider powers than those invested in the Conservator of Forests by the earlier legislation. In addition to protecting and preserving existing fringing forests. It permits of replanting operations being carried out at the public expense wherever the Medical Authorities consider desirable.

"Summarizing the above, it may be generally assumed that the headwaters and approximately half the lengths of the principal rivers lie within Crown (Forest) Land and are, therefore, permanently and satisfactorily protected. The lower half of the lengths of most, if not all the rivers and watercourses, lie within privately owned lands, and, as is to be expected, protection of 'River Reserves' is neither appreciated nor practised by many riparian owners. Every effort is made to enforce the provisions of the protective ordinances, but surveillance staff is inadequate and with extremely acute pressure on the land evasion and encroachment is all too commonly practised.

"In addition to the circumstances described above, the more or less unregulated introduction of exotics in the past has greatly influenced the situation. Apart from the large number of plant species deliberately introduced for specific purposes, an extremely effective number of weedy plants—grasses and herbs—have found their way into the island and successfully established themselves. Many of these exotics have proved themselves astonishingly adaptable and there now remain only very few and insignificantly small areas of natural forest within which the original plant associations survive in the pure state. Perhaps the most widespread and, for this reason important, of the exotics which have established themselves in Mauritius are (i) '*Herbe Conde*' (*Cordia macrostachys*), (ii) the so-called '*Chinese Guava*' (*Psidium cattleysnum*), and (iii) the '*Privet*' (*Ligustrum walkeri*). The first occurs principally at low to medium elevations but is found also at high elevations ; the '*Chinese Guava*' occurs at from medium to high elevations ; as does the '*Privet*'. All three have achieved a deserved notoriety, and in any part of the island one may choose to visit it is almost

impossible to escape from the company of at least one of the trio. In view of these facts it is safe to say that none of the 'fringing forests and natural vegetation' along the banks of the principal rivers retain their natural form or original character.

"The table below gives the names of the principal rivers of the island, starting from the North and travelling clockwise, with their approximate lengths. No attempt has been made to provide corresponding figures for the tributaries and feeders of each.

Serial No.	Name of River	Approx. length (miles)	Remarks
1	Riviere du Rempart	12–15	Rising in forest and flowing through cultivated lands.
2	Riviere du Poste (i) ..	8–10	do.
3	Grande River South-East ..	25–30	do.
4	Riviere Creoles	8–10	do.
5	,, du Poste (ii) ..	20–25	do.
6	,, des Aiguilles	12–15	do.
7	,, Pailles	6–8	do.
8	,, St. Denis-du-Cap ..	7–10	do.
9	,, Noire	7–10	do.
10	River Tamarin	11–15	do.
11	Grand River North-West ..	12–16	do.
12	Riviere du Tombeau	6–8	do.
13	,, Citron	9–12	do.

Note :—The lengths indicated are only very approximate. No precise measurements of individual rivers has ever been made and the best maps available locally are no more than topographical maps on the 1″ = 1 mile scale, which are known to be inaccurate. My estimates of lengths are based on measurements taken from these maps.

"I think it is safe, and reasonably accurate, to state that the "fringing forests" of rivers included within Crown (Forest) Lands do, in large measure, retain much of their original form ; that is as far as the principal plant associations are concerned, and that the general figure of say 35–40% of the total lengths of the rivers may be applied to these forests. My remarks apply more accurately, of course, to the forests included within the 'River Reserves' ".

(To be continued)

TREATMENT OF INDIAN TIMBERS FOR PENCILS

AND

HAND TOOLS FOR PENCIL MAKING

BY M. A. REHMAN AND JAI KISHEN

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SUMMARY

The article describes the method of softening light hard-woods for pencils and also gives the details of the hand tools designed at the Forest Research Institute for the making of pencils as a cottage industry.

TREATMENT OF TIMBERS FOR PENCILS

Of the various types of writing pencils, the wood-cased lead pencil is the most common. The present shape of this pencil and the basic method of its manufacture we owe to Nicholas Jacques Conte, a French painter. The raw materials required in the making of the pencil are graphite, wood, clay, glue, waxes, oils, dyes, printing foils, lacquers, shellac, spirit, etc. Of these, wood is the most costly.

At present India is consuming about 5,00,000 gross pencils annually. This is equivalent to 1/5 pencil per head per year. The consumption of pencils in the country is likely to increase considerably in the future. India needs over 1,00,000 cubic feet of sawn timber to meet her present annual demand of the pencil industry.

There are very few species of timbers in the world, available in sufficient quantity, which can be utilized for good quality pencils. In the Forest Bulletin No. 149, issued by the Forest Research Institute, Dehra Dun, it has been shown that in deodar (*Cedrus deodara*) India possesses one such timber, but deodar is already finding several uses, and as far as possible its use as pencil wood should be supplemented by the exploitation of other indigenous species.

Cypress (*Cupressus torulosa*) and the Himalayan pencil cedar (*Juniperus macropoda*) are two more timbers really satisfactory for pencils though the pale yellow colour of the former requires to be improved. The supplies of both the species are extremely scanty. However, they can be utilized with profit on the cottage scale in the localities in which they are found. *Callitris rhomoboidea* growing in the Nilgiri hills, though a bit hard, has been found to possess the smoothness necessary in a pencil wood. The growth of this species is so defective and the yield so poor, that its utilization by the pencil industry may not be economic. *Kail* (*Pinus excelsa*), the best of the Indian pines, is easy to cut. However, it is not considered suitable for pencils on account of its coarser texture. There is no other conifer in India known to possess the qualities required for pencil making.

Hardwoods do not posses even texture. They are also porous. As a result of these structural peculiarities, hardwoods lack the smooth cutting qualities required of a pencil wood. In some cases these characteristics can be imparted to them by suitable treatment. Investigations carried out at the Forest Research Institute, Dehra Dun, on the use of hardwoods for pencil making, have shown that some close and straight grained light hardwoods turn out to be satisfactory for pencil making after they have been given the requisite treatment. To this class belong *kuthan* (*Hymenodictyon excelsum*), *banati* (*Lophopetalum wightianum*), *champ* (*Michelia champaca*) and probably several other species.

Treatment.—The treatment that is given to the pencil slats of the above mentioned timbers consists in impregnating them with paraffin wax dyed red, to the extent of 10 to 15% of the weight of the slats. The function of the red dye in the wax is to stain the slats to the pencil cedar shade. The details of the treatment are given below.

The timber to be treated is seasoned and cut into pencil slats of the standard size. The slats are formed into a stack inserting thin strips of wood as crossers, leaving thereby small spaces between the adjacent slats. Match wax may be used for impregnation. The wax is melted in an iron tank and it is dyed deep red with, say, Waxoline Red BNS. of M/s. Imperial Chemical Industries (India) Ltd. The temperature of the melted wax is raised to 80°C and the stack of slats to which a sinker has been fixed is lowered into the wax and kept stirred. The wax is then allowed to cool. During this cooling the slats absorb wax.

Since the slats are cut from porous wood, the absorption of wax by them is very rapid. The slats of *Lophopetalum wightianum* are choked with wax in the course of a few minutes. To control the absorption two methods are suggested. The first method is based on the fact that the quantity of wax absorbed by the slats depends upon its range of cooling. *Kuthan* slats absorb a little over 10% wax when the wax cools by 15°C (from 80°C to 65° C). In large scale treatment, preliminary experiments will have to be conducted to find a relation between the percentage wax absorbed and its range of cooling for the timber under treatment.

According to the second method the slats are weighed before stacking. The stack when it is immersed in the wax, is suspended freely from a spring balance or some improvised weighing beam which will indicate, though partially, the quantity of wax undergoing absorption by the slats. Again by a preliminary experiment the relation between the actual amount of wax absorbed and the amount indicated by the weighing machine is obtained. In the treatment the stack of slats is withdrawn from the tank after the slats have absorbed about 10 to 15% wax which figure is roughly estimated from the readings of the weighing device.

The absorption of wax is only superficial. To diffuse it uniformly the stacks are kept at a temperature of 60°C to 65°C for a few hours in a hot air room. Although the absorption of wax is almost independent of how the slats are sawn, its diffusion is materially affected by their way of cutting. While the tangentially sawn slats are uniformly stained and impregnated with wax after a few hours of diffusion, the radial slats take considerably longer time.

Pencil Making.—A pencil factory generally accepts wood in the form of narrow, thin pieces about 7″ long, 2″ or $2\frac{5}{8}$″ wide and 3/16″ thick, which are called pencil slats. For the manufacture of pencils, the slats are first passed through a grooving machine which cuts equidistant semicircular grooves only on one face of the slat. This face also gets planed. Then the slats are glued together in blocks of two with the leads sandwiched in the grooves. After pressing, drying and squaring of the ends, the blocks are converted into pencils by a moulding machine. This is followed by sanding and finishing operations including lacquering and stamping.

HAND TOOLS FOR PENCIL MAKING

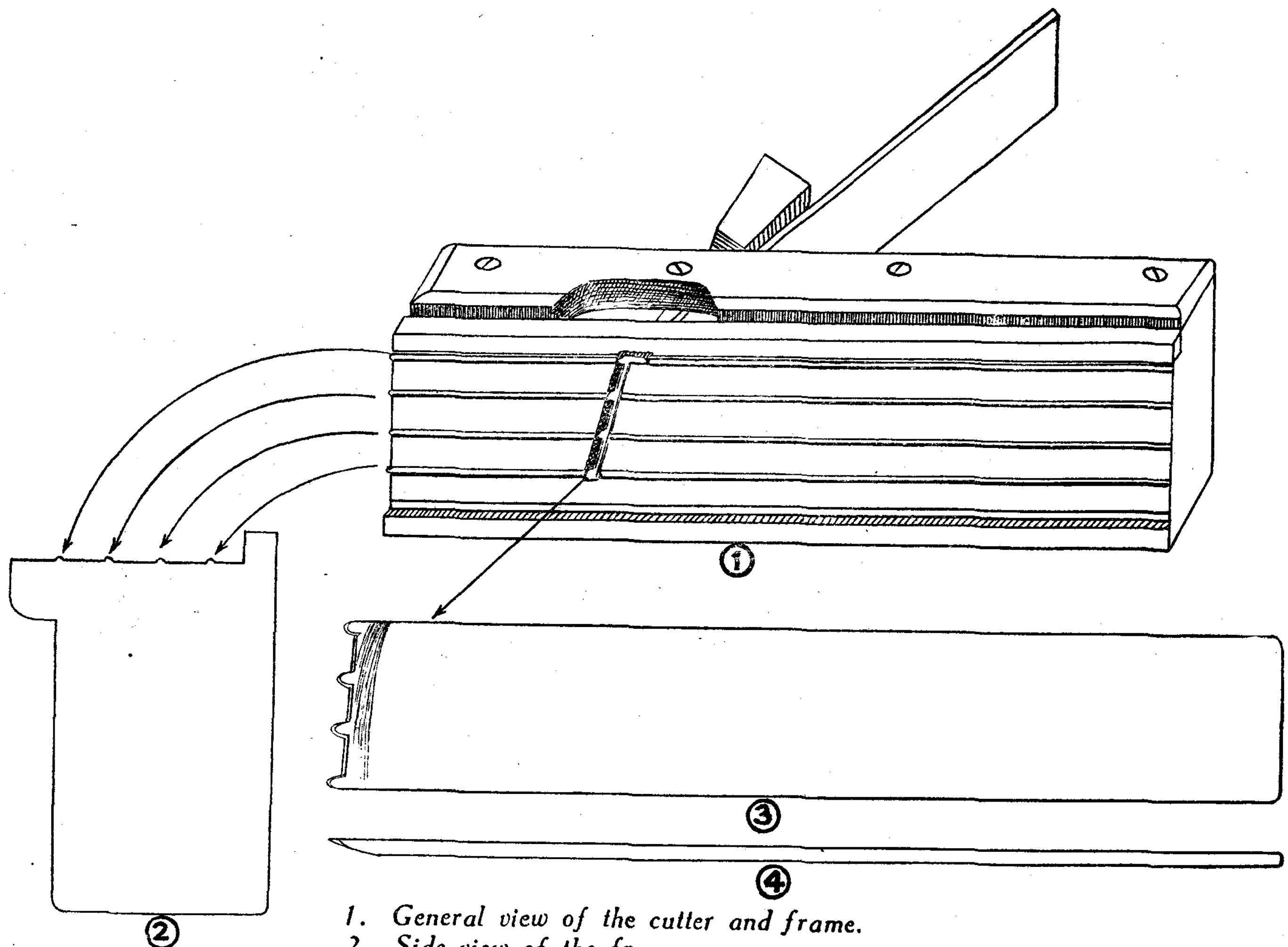
Pencils can also be made by hand. The various operations here are the same as those in machining. Starting from the slat stage, a good worker should at least shape as many as one gross pencils per day. The tools required for the purpose are a simple plane, a grooving, a round cutting and a round smoothing plane. The description of various tools is given below:—

(1) *Simple plane*.—It is an ordinary plane with which one face of the slats is planed smooth.

(2) *Grooving plane*.—This plane cuts grooves on the smoothed face of the slats for taking the leads. In appearance this plane is like an ordinary plane except for

GROOVING PLANE

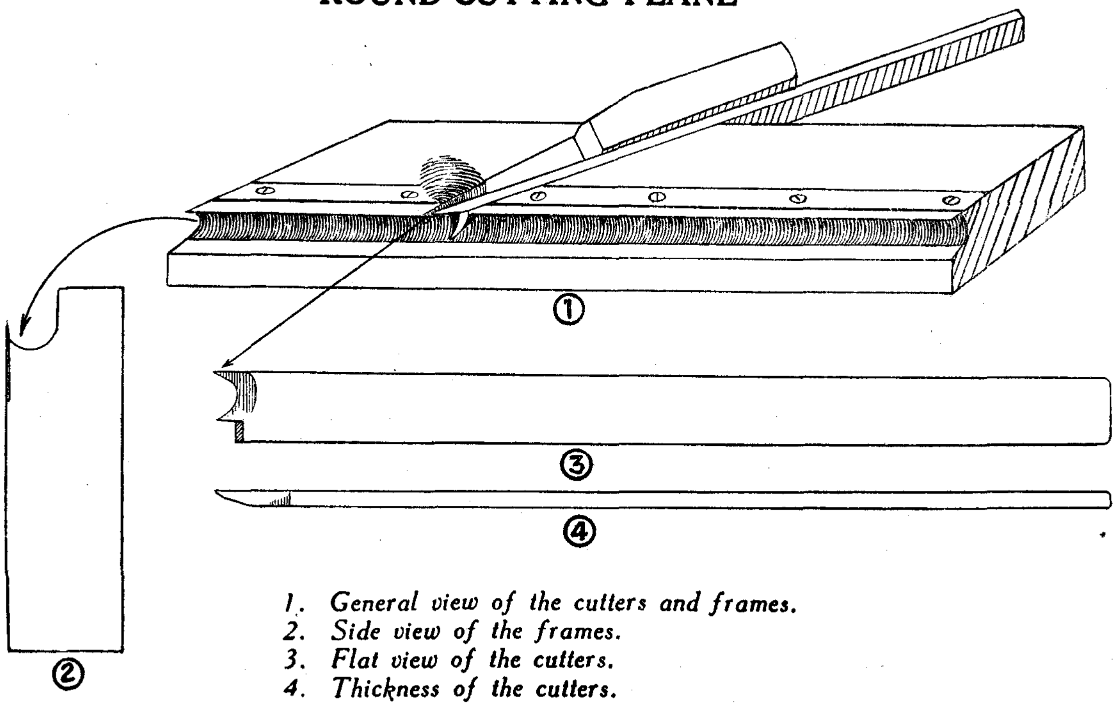
Plate I



1. *General view of the cutter and frame.*
2. *Side view of the frame.*
3. *Flat view of the cutter.*
4. *Thickness of the cutter.*

ROUND-CUTTING PLANE

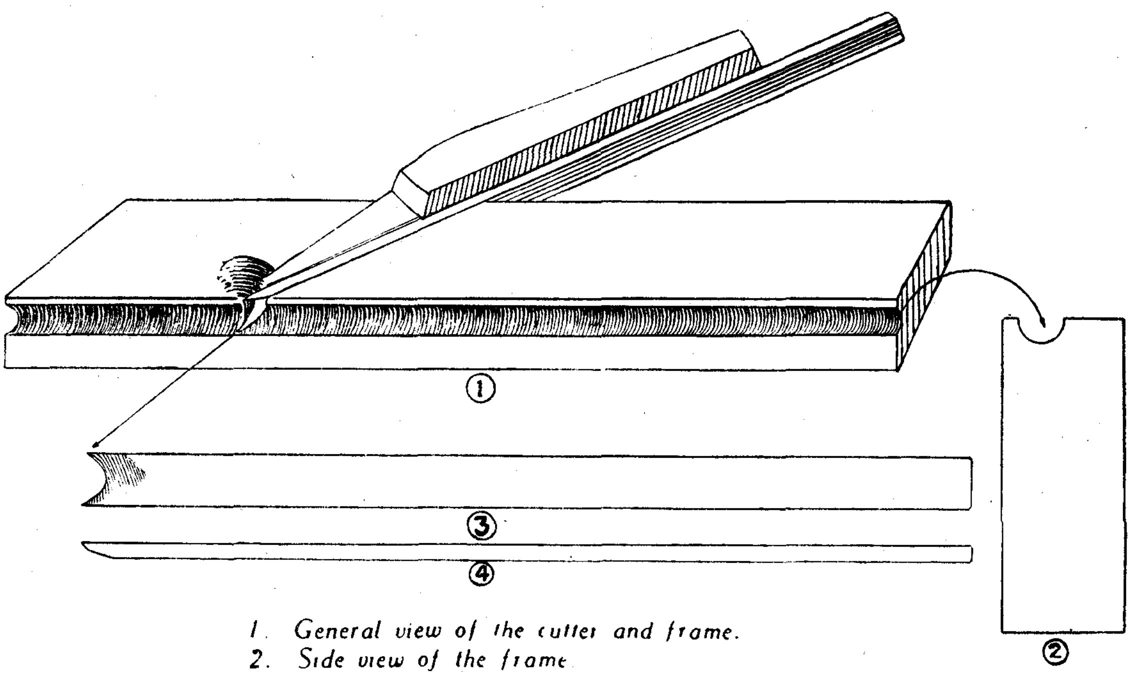
Plate II



1. General view of the cutters and frames.
2. Side view of the frames.
3. Flat view of the cutters.
4. Thickness of the cutters.

ROUND-SMOOTHING PLANE

Plate III



1. General view of the cutter and frame.
2. Side view of the frame.
3. Flat view of the cutter.
4. Thickness of the cutter.

the small wooden fence fixed to the side of the plane to act as a guide for getting straight grooves. The cutter of the plane is provided with a number of rounded teeth for ploughing the grooves. The distance between the centres of the adjacent teeth is nearly equal to the diameter of the pencils to be made. The size of the teeth is equal to half the cross section of the leads to be put into the pencils. Running longitudinally on the face of the plane, in line with the teeth of the cutter, are fixed moulds of compressed wood or ordinary wood of high abrasive resistance. These moulds which are semicylinderical like half leads, are meant for giving similar shape to the grooves. The grooving planes to be worked on 2″ and $2\frac{5}{8}$″ slats should have three and four teeth repectively.

(3) *Round cutting plane.*—After the slats have been grooved, they are "leaded" and glued in blocks of two. In the next operation the round cutting plane rounds as well as cuts a half pencil on one face of a glued block. Then it is worked on the other face to complete the pencil and so on. This plane has one half round hollow cutter with slightly elongated ends set in a semicircular groove which runs along the whole length of the plane. The size of the half round hollow cutter and the groove is slightly bigger than half the cross section of the pencil. The inclination of the blade of the cutter to the horizontal is the same as in the grooving plane, but it is turned a little on the vertical axis. The round cutting plane is also provided with the side fence.

It is possible to mould two or more pencils at one time by having as many half round cutters in the blade. But the exertion involved will be too much for continuous work.

(4) *The Round smoothing plane.*—The surface of the pencils obtained after the last operation is rough. It is made smooth by the round smoothing plane. The cutter of this plane is like that of the previous plane but the ends of the half round hollow are not elongated. The size of the half round hollow and the groove in which it is set is exactly equal to that of half pencil. During this operation the pencil to be smoothed, is placed in semicircular groove made on the working table. This groove is also of the same size as half pencil.

After the pencils have been made, they are sanded and finished as desired. The rate of production of the pencils is increased appreciably if the length of the slats is doubled and each big pencil obtained is cross cut into two before the finishing operations.

The sketches of the grooving, round cutting, and round smoothing planes are given in Plates I, II and III.

In conclusion it is acknowledged that Mistri Kalu Ram, Cabinet Maker of the Wood Work Shop, Forest Research Institute and Colleges, designed the various tools and demonstrated their use. Thanks are also due to the Forest Entomologist for getting the drawings of the cutters made by his artist.

CLASSIFICATION OF INDIAN TIMBERS BASED ON THEIR WEIGHT PER CUBIC FOOT

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There are a number of classifications beginning with that of Troup published in the *Indian Forest Utilization* 1907. According to this the following scale was suggested.

	lb.
Very light	under 30
Light	30 to 40
Moderately heavy	40 to 50
Heavy	50 to 60
Extremely heavy	70 and over

Another classification given by Dr. K. A. Chowdhury in *Forest Bulletin* No. 77 of 1932 is as follows :—

	lb.
Very light	18 to 22
Light	22 to 27
Moderately light	27 to 32
Moderately heavy	32 to 39
Heavy	39 to 49
Very heavy	50 and over

In the Manual of *Indian Forest Utilization* by H. Trotter, 1940, the classification has been suggested as below :—

	lb.
Very light	up to 22
Light	23 to 27
Moderately light	28 to 32
Moderately heavy	33 to 39
Heavy	40 to 49
Very heavy	over 49

In the Commercial Timbers of Australia, their properties and uses by I. H. Boas, timbers have been grouped with mean values of lb. per c. ft., as follows :—

	lb.
Mean value under	20
Do.	20 to 25
Do.	25 to 30
Do.	60 to 65
Do.	65 to 70
Do.	over 70

In all these cases the weight of wood is reckoned as that of 12% moisture content more or less.

In a scheme of classification for defining the various classes the first point that should be considered is that the classes should differ by an equal specified quantity or weight. In

our opinion 14 lb., i.e., half a quarter appears to be a suitable number to adopt. We have analysed the recorded weights of all the Indian timbers in Vols. I and II of COMMERCIAL TIMBERS OF INDIA by R. S. Pearson and H. B. Brown (1932) and find that our scheme of classification, which we suggest for consideration below, seems to fit in in the lists very well. This list is accordingly published for information and inviting criticisms to evolve a final standard for Indian timbers.

(The actual weight of the timbers is shown in brackets against each).

VERY LIGHT (15–28)

1. *Abies pindrow, Spach* (*27*).
2. *Acer thomsoni, Miq.* (*26*).
3. *Ailanthus excelsa, Roxb.* (*27*).
4. *Alnus nitida, Endl.* (*28*).
5. *Alstonia scholaris, R. Br.* (*26–30 = 28*).
6. *Bombax insigne, Wall.* (*24*).
7. *Bombax malabaricum, DC.* (*25*).
8. *Canarium euphyllum, Kurz.* (*26*).
9. *Canarium sikkimense, King* (*19*).
10. *Cedrela serrata, Royle* (*28*).
11. *Duabanga sonneratioides, Ham.* (*24*).
12. *Litsœa polyantha, Juss.* (*26*).
13. *Lophopetalum wightianum, Arn.* (*28*).
14. *Melia composita, Willd.* (*21*).
15. *Parishia insignis, Hook. f.* (*24*).
16. *Populus ciliata, Wall.* (*20*).
17. *Salix tetrasperma, Roxb.* (*24*).
18. *Spondias mangifera, Will.* (*23*).
19. *Sterculia alata, Roxb.* (*24*).
20. *Sterculia campanulata, Wall.* (*21*).
21. *Sterculia villosa, Roxb.* (*17*).
22. *Tetrameles nudiflora, R. Br.* (*22*).
23. *Trewia nudiflora, Linn.* (*22*).

LIGHT (29–42)

1. *Acer cœsium, Wall.* (*37*).
2. *Acer campbellii, Hook. f. et Thoms.* (*37*).
3. *Adina cordifolia, Hook. f.* (*40–42 = 41*).
4. *Aesculus indica, Colebr.* (*35*).
5. *Albizzia lebbek, Benth.* (*39*).
6. *Albizzia lucida, Benth.* (*41*).
7. *Albizzia procera, Benth.; Sapwood* (*29*).
   Do. Do. Heartwood (*40*).
8. *Alnus nepalensis, Don.* (*37*).
9. *Amoora rohituka, Wight et Arn.* (*35*).
10. *Amoora wallichii, King* (*33*).
11. *Anthocephalus cadamba, Miq.* (*34*).
12. *Aquilaria agallocha, Roxb.* (*31*).
13. *Artocarpus chaplasha, Roxb.* (*30–32 = 31*).
14. *Artocarpus hirsuta, Lamk.* (*37*).
15. *Artocarpus lakoocha, Roxb.* (*32, 33 = 33*).
16. *Barringtonia acutangula, Gaertn.* (*37*).
17. *Bauhinia purpurea, Linn.* (*36*).
18. *Betula alnoides, Ham.* (*41*).
19. *Betula cylindrostachys, Gamble* (*38*).
20. *Bœhmeria rugulosa, Wedd.* (*32*).
21. *Boswellia serrata, Roxb.* (*36*).
22. *Buchanania augustifolia, Roxb.* (*38*).
23. *Buchanania latifolia, Roxb.* (*29*).
24. *Bucklandia populnea, R. Br.* (*40*).
25. *Butea frondosa, Roxb.* (*34*).
26. *Callicarpa arborea, Roxb.* (*35–38 = 37*).
27. *Calophyllum tomentosum, Wight* (*33–41 = 37*).
28. *Calophyllum spectabile, Willd.* (*41*).
29. *Calophyllum wightianum, Wall.* (*41–43 = 42*).
30. *Canarium strictum, Roxb.* (*38*).
31. *Castanopsis hystrix, A.DC.* (*42*).
32. *Castanopsis indica, A.DC.* (*40*).
33. *Cedrela toona, Roxb.* (*37*).
34. *Cedrus deodara, Linn.* (*35*).
35. *Celtis australis, Linn.* (*38*).
36. *Chukrasia tabularis, Adr.* (*40*).
37. *Cinnamomum cecicodaphne, Meissn.* (*36*).
38. *Cinnamomum zeylanicum, Breyn.* (*39*).
39. *Cordia myxa, Linn.* (*34*).
40. *Cullenia excelsa, Wight* (*32–39 = 36*).
41. *Cupressus torulosa, Don.* (*30–32 = 31*).
42. *Dillenia indica, Linn.* (*40*).
43. *Dillenia parviflora, Griff.* (*42*).
44. *Dillenia pentagyna, Roxb.* (*39–43 = 41*).
45. *Echinocarpus dasycarpus, Benth.* (*32*).
46. *Ehretia lœvis, Roxb.* (*39*).
47. *Elœocarpus lanceœfolius, Roxb.* (*36*).
48. *Elœocarpus robustus, Roxb.* (*39*).
49. *Elœocarpus tuberculatus Rox.* (*29*).
50. *Elœocarpus ferrugineus, Bedd.* (*38*).
51. *Hydrocarpus wightiana, Blume* (*35*).
52. *Hymenodictyon excelsum, Wall.* (*32*).
53. *Juglans regia, Linn.* (*33*).
54. *Kydia calycina, Roxb.* (*31*).
55. *Lagerstrœmia flos reginœ, Retz.* (*40*).
56. *Lagerstrœmia hypoleuca, Kurz.* (*42*).
57. *Lannea grandis, Eng.* (*36*).
58. *Litsœa umbrosa, Nees* (*30*).
59. *Machilus gamblei, King* (*33*).
60. *Machilus gammieana, King* (*35*).
61. *Machilus macrantha, Nees* (*33*).
62. *Machilus odoratissima Nees* (*30*).
63. *Mangifera indica, Linn.* (*38*).
64. *Mangifera sylvatica, Roxb.* (*33, 35 = 34*).
65. *Melia azedarach, Linn.* (*36*).
66. *Michelia champaca, Linn.* (*31–34 = 33*).
67. *Michelia excelsa, Blume* (*32–35 = 34*).
68. *Michelia nilagirica, Zenkar* (*41*).
69. *Morinda tinctoria, Roxb.* (*34*).
70. *Morus alba, Linn.* (*40*).
71. *Morus lœvigate, Wall.* (*38*).
72. *Myristica attenuata, Wall.* (*33*).
73. *Myristica canarica, Bedd.* (*33*).
74. *Myristica irya, Gœrtn.* (*37*).
75. *Nyssa sessiliflora, Hook. f.* (*39*).
76. *Picea morinda, Link* (*29*).
77. *Pinus excelsa, Wall.* (*32*).
78. *Pinus khasya, Royle* (*35*).
79. *Pinus longifolia, Roxb.* (*33, 38 = 36*).

LIGHT (29–42)—(*concld.*)

80. *Podocarpus neriifolia, Don.* (*34*).
81. *Pongamia glabra, Vent.* (*37*).
82. *Prunus padus, Linn.* (*34*).
83. *Pterospermum acerifolium, Wild.* (*39*).
84. *Rhododendron arboreum Sm.* (*36*).
85. *Shorea assamica, Dyer* (*36*).
86. *Sonneratia apetala, Ham.* (*38*).
87. *Stephegyne diversifolia Hook. f.* (*41*).
88. *Stephegyne parvifolia, Korth.* (*40*).
89. *Sterculia urens, Roxb.* (*37, 38 = 38*).
90. *Stereospermum chelonoides, DC.* (*33–35 = 34*).
91. *Stereospermum suaveolens, DC.* (*42*).
92. *Taxus baccata, Linn.* (*37*).
93. *Tectona grandis, Linn. f.* (*38, 43 = 41*).
94. *Terminalia belerica, Roxb.* (*37*).
95. *Terminalia catappa, Linn.* (*42*).
96. *Terminalia myriocarpa, Heurck et Muell. Arg.* (*39*).
97. *Terminalia procera, Roxb.* (*37–44 = 41*).
98. *Ulmus wallichiana, Planch.* (*39*).
99. *Vateria indica, Linn.* (*36*).
100. *Vitex leucoxylon, Linn. f.* (*39*).
101. *Wrightia tinctoria, R. Br.* (*36*).
102. *Wrightia tomentosa, Rœm. etc. Schultes* (*32*).
103. *Zanthoxylum budrunga, Wall.* (*41*).
104. *Zanthoxylum rhetsa, DC.* (*42*).
105. *Zizyphus jujuba, Lamb.* (*41*).

HEAVY (43–56)

1. *Acacia arabica, Willd.* (*51*).
2. *Acacia leucophlœa, Willd.* (*45*).
3. *Acer oblongum, Wall.* (*45*).
4. *Acer pictum, Thunb.* (*47*).
5. *Acrocarpus fraxinifolius, Wight* (*43*).
6. *Albizzia amara, Boivin* (*54*).
7. *Albizzia odoratissima, Benth.* (*43*).
8. *Albizzia stipulata, Boivin* (*46*).
9. *Altingia excelsa, Noronha* (*48*).
10. *Anogeissus acuminata, Wall.* (*51–55 = 53*).
11. *Azadirachta indica, A. Juss.* (*44*).
12. *Bauhinia malabarica, Roxb.* (*43*).
13. *Bauhinia retusa, Ham.* (*45*).
14. *Bischofia javanica, Blume* (*47*).
15. *Bridelia retusa, spring.* (*47*).
16. *Bursera serrata, Colebr.* (*50*).
17. *Buxus wallichiana, Baill.* (*52*).
18. *Canthium didymum, Roxb.* (*46*).
19. *Carallia lucida, Roxb.* (*43*).
20. *Carapa moluccensis, Lamk.* (*49*).
21. *Carapa obvata, Blume* (*43*).
22. *Careya arborea, Roxb.* (*46*).
23. *Cassis fistula, Linn.* (*50*).
24. *Casuarina equisetifolia, Frost.* (*56*).
25. *Chloroxylon swietenia, DC.* (*54*).
26. *Cordia macleodii, Hook. f. etc., Thoms.* (*46*).
27. *Cordia vestita, Hook, f. et Thoms.* (*51*).
28. *Dalbergia lanceolaria, Linn.* (*41, 48 = 45*).
29. *Dalbergia latifolia, Roxb.* (*53*).
30. *Dalbergia sissoo, Roxb.* (*50, 53 = 52*).
31. *Diospyros melanoxylon, Roxb.* (*53, 56 = 55*).
32. *Diospyros tomentosa, Roxb.* (*53*).
33. *Dipterocarpus costatus, Gœrtn. f.* (*44, 49 = 47*).
34. *Dipterocarpus griffithii, Miq.* (*45*).
35. *Dipterocarpus indicus, Bedd.* (*43*).
36. *Dipterocarpus pilosus, Roxb.* (*45*).
37. *Dipterocarpus turbinatus, Gœrtn. f.* (*40–48 = 44*).
38. *Dysoxylum binectariferum, Hook. f.* (*45*).
39. *Dysoxylum malabaricum, Bedd.* (*47*).
40. *Eriolœna candollei, Wall.* (*48–53 = 51*).
41. *Lagerstrœmia lanceolata, Wall.* (*45*).
42. *Lagerstrœmia parviflora, Roxb.* (*47, 48 = 48*).
43. *Litsœa sebifera, Pers.* (*43*).
44. *Mallotus philippinensis, Muell. Arg.* (*48*).
45. *Miliusa velutina, Hook. f. et Thoms.* (*46*).
46. *Morus serrata, Roxb.* (*43*).
47. *Murraya exotica, Linn.* (*53*).
48. *Ouginia dalbergioides, Benth.* (*54*).
49. *Palaquium ellipticum, Benth.* (*43*).
50. *Phyllanthus emblica, Linn.* (*49*).
51. *Pistacia integerrima, Stewart* (*49*).
52. *Pœciloneuron indicum, Bedd.* (*55*).
53. *Polyalthia cerasoides, Benth. et Hook. f.* (*44*).
54. *Polyalthia simiarum, Benth. etc., Hook. f.* (*44*).
55. *Prunus puddum, Roxb.* (*45*).
56. *Pterocarpus dalbergioides, Roxb.* (*48*).
57. *Pterocarpus marsupium, Roxb.* (*48–50 = 49*).
58. *Quercus incana, Roxb.* (*47*).
59. *Quercus serrata, Thunb.* (*54*).
60. *Quercus semecarpifolia, Smith* (*35*).
61. *Randia dumetorum, Lamk.* (*48*).
62. *Rhizophora mucronata, Lamk.* (*52*).
63. *Sagerœa elliptica, Hook. f. et Thom.* (*51–54 = 53*).
64. *Schima wallichii, Choisy* (*46*).
65. *Schrebera swietenioides, Roxb.* (*54*).
66. *Shorea robusta, Gœrtn. f.* (*50–56 = 53*).
67. *Shorea talura, Roxb.* (*48*).
68. *Sideroxylon tomentosum, Roxb.* (*51*).
69. *Stereospermum xylocarpum, Benth. et Hook. f.* (*46*).
70. *Strychnos potatorum, Linn. f.* (*50*).
71. *Strychnos nux-vomica, Linn.* (*55*).
72. *Talauma hodgsoni, Hook. f. et Th.* (*46*).
73. *Tamarix articulata, Vohl.* (*44*).
74. *Terminalia arjuna, Bedd.* (*47*).
75. *Terminalia bialata, Steudel* (*43*).
76. *Terminalia manii, King* (*51*).
77. *Terminalia paniculata, Roth.* (*48*).
78. *Terminalia tomentosa, Wight et Arn.* (*46, 54 = 50*).
79. *Ulmus lancifolia, Roxb.* (*53*).
80. *Vitex altissima, Linn. f.* (*51*).
81. *Xylia xylocarpa, Taub.* (*52–59 = 56*).
82. *Zizyphus xylopyrus, Willd.* (*49*).

VERY HEAVY (57–70)

1. *Acacia catechu, Willd.* (*63*).
2. *Acacia ferruginea, DC.* (*63*).
3. *Acacia modesta, Wall.* (*62*).
4. *Aegle marmelos, Correa* (*57*).
5. *Anogeissus latifolia, Wall.* (*51, 60, 62 = 58*).
6. *Anogeissus pendula, Edgew.* (*62*).
7. *Atalantia monophylla, Correa* (*59*).
8. *Balanocarpus utilis, Bedd.* (*65*).
9. *Bassia latifolia, Roxb.* (*62.*)
10. *Bassia longifolia, Linn.* (*61*).
11. *Berrya ammonilla, Roxb.* (*65*).
12. *Bruguiera gymnorhiza, Lam.* (*61*).
13. *Calophyllum inophyllum, Linn.* (*58*).
14. *Diospyros marmorata, Parker* (*63*).

VERY HEAVY (57–70) —(*concld.*)

15. *Kayea assamica, King et Prain* (*55–58 = 57*).
16. *Limonia acidissima, Linn.* (*61*).
17. *Mesua ferrea, Linn.* (*60–65 = 63*).
18. *Mimusops elengi, Roxb.* (*67*).
19. *Mimusops hexandra, Roxb.* (*70*).
20. *Mimusops littoralis, Kurz.* (*68*).
21. *Olea ferruginea, Royle* (*66*).
22. *Pterocarpus santalinus, Linn. F.* (*63*).
23. *Quercus dilatata, Lindley* (*60*).
24. *Quercus lamellosa, Smith* (*61*).
25. *Santalum album, Linn.* (*59*).
26. *Schleichera trijuga, Willd.* (*59*).
27. *Shorea tumbuggaia, Wight et Arn.* (*60*).
28. *Terminalia chebula, Retz.* (*59*) (*56, 59, 63 = 59*).
29. *Vitex pedunucularis, Wall* (*61*).

EXTREMELY HEAVY (71 and over)

1. *Diospyros ebenum, Koenig* (*72*).
2. *Soymida febrifuga, Adr. Juss.* (*73*).

NOTE BY THE WOOD TECHNOLOGIST

For the last 20 years, there has been in use a set of terms for describing the weight of Indian timbers. From the beginning, these terms were not considered perfect. But they were in use in the U.S.A. and seemed to serve our purpose. A more suitable set of terms will undoubtedly be an advantage. We should, however, at the same time try not to upset the previous classification of weights to such an extent as to bring in a confusion in our literature. Teak has been taken as the standard for all our timbers. The terms used for the weight of teak should, therefore, remain as far as possible undisturbed. With this object in view we submit below some modifications to Mr. Prasad's classification of weight of timbers. The idea underlying Mr. Prasad's classification is excellent. He has suggested 4 main classes with a difference of 14 lb. between one another. We are of opinion that these 4 classes may be further divided into eight sub-classes with a difference of 7 lb. and suitable modifying adjectives be attached to them. The suggested classification is given below :—

Light	14–21	very light
	21–28	light
Medium	28–35	medium light
	35–42	medium heavy
Heavy	42–49	heavy
	49–56	very heavy
Weighty	56–63	weighty
	63 or more	very weighty (heavier than water)

Acknowledgement is due to Mr. C. R. Ranganathan, President, Forest Research Institute, for his suggestions and helpful discussions on this classification.

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A PRELIMINARY NOTE ON ADHESIVES, BUILDING BOARDS AND MOULDING POWDERS FROM TREE BARKS

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In an earlier paper (Indian Forest Leaflet No. 118) some experiments on the utilization of tree barks were recorded. Some of the uses mentioned were production of insulation wool and building boards. Since then further experiments have been in progress in this laboratory with particular reference to (*a*) production of building boards, (*b*) moulding powders and (*c*) plywood adhesives from barks. This note briefly describes the preliminary results obtained with particular reference to (*b*) and (*c*).

Tannin-formaldehyde resins have been the subject of study from time to time (Mc Coy, 1918, Kessler 1932, Morgan and Megson 1937). Philips and Rottsieper (1942) made plastic materials from some barks by mixing them with hexamine or paraformaldehyde before moulding. Recently Dalton (1950) has described tannin-formaldehyde resin adhesives.

There are a number of Indian barks rich in tannin. So it was thought of interest to study the production of boards, moulding powders and adhesives both from barks as well as from wood (saw dust) containing tannins. Among the species so far studied may be mentioned : sal (*Shorea robusta*), cutch (*Acacia catechu*), *Acacia mollisima* and *Callitris* sp. Studies on other barks as well as fruits and leaves rich in tannins are being undertaken. In addition we have also investigated Katha* for preparation of adhesives.

ADHESIVES

For the preparation of adhesives *Acacia catechu* bark extracts as well as Katha were tried. Satisfactory adhesives from Katha were obtained by addition of about an equal weight of furfural, some spirits and a catalyst like lime (5 to 10% on Katha) or sodium hydroxide. An adhesive made by mixing 20 gms. of Katha, 20 gms. of furfural, 30 cc. of rectified spirits and 1 gm. of lime, when applied to both faces of 1/16″ veneers and pressed at 160°C for 10 mins. at 200 lb./sq. in. gave dry strengths of 140–190 lb./sq. in. with predominant wood failure and hot wet (three hours boiling) strengths of 125–160 lb./sq. in. Using sodium hydroxide in place of lime and with addition of small quantities of hexamine, urea, or sulphur, dry strengths up to 300 lb./sq. in. and hot wet strengths up to 200 lb./sq. in. were obtained. Addition of cashew shell oil and cuprammonium solutions was also beneficial.

A few preliminary experiments were also done to investigate the possibilities of making "veneer film adhesives". For this purpose thin veneers from the heartwood of *Acacia catechu* were used. They were soaked in formalin solution and sodium hydroxide was used as catalyst. Though adhesion was obtained this has to be further improved.

In another series of experiments kraft paper was soaked in the extract (16% solid content) of *Acacia mollissima* bark overnight. The paper was then allowed to dry in air. This was used as the adhesive film for making plywoods. Just before pressing, the treated paper film was dipped in a tannin solution of the following composition :

10 gms. of tannin (Katha),
25 cc. of rectified spirits,
5 cc. of formalin.

The veneers were painted with 3% lime solution. The pack was pressed at 150°C for 5 mins. at 200 lb./sq. in. for 3/16″ three ply boards.

Ply-boards so prepared had good adhesion and at the end of 2 hours boiling had an adhesive strength of 155 lb./sq. in.

* *Katha* is crude catechin prepared by extracting the heartwood of *Acacia catechu* with boiling water and then allowing the extract to crystallise.

MOULDED PRODUCTS

Sal bark powder mixed with paraformaldehyde or hexamine could be moulded. The results of some of the experiments are given below. In these experiments an improvised moulding equipment was used.

1	2	3	4	5	6	7	8	9	10
No.	Composition of moulding powder	Preparation of the powders	Moulding conditions	Weight of the product	Water absorption (in %) 24 hours	Water absorption (in %) 48 hours	Water absorption (in %) 1 week	Water absorption (in %) 15 days	REMARKS
1	25 gm. deodar saw dust 0·5 gm. (sulphur 2%) 10 cc. N/10 NaOH (0·04 gm.) 1 cc. phenol (4%) 1 cc. formaline	Autoclaved for 4 hours at 60 lb./sq. in. Dried then 0·5 gm. of aluminium stearate mixed.	Pressed in a jack for ½ hr. and heated	22·85 gm.	8 in 42 hrs.	..	..	..	Up to 7 days (in water) it was in good condition.
2	25 gm. sal bark powder 1·0 gm. paraformaldehyde 0·5 gm. of aluminium stearate	Mixed thoroughly and put in the mould	do.	25·05 gm.	10 in 42 hrs.	..	..	..	do.
3	25 gm. of sal bark powder 0·5 gm. sulphur 10 cc. N/10 NaOH.	Autoclaved for 1½ hrs. at 50 lb./sq. in. then dried	do.	..	Broken	..	..	..	..
4	25 gm. sal bark powder 0·5 gm. hexamine 1 cc. glycerol 1 cc. furfural	Mixed thoroughly and put in mould	do.	27·00	6·3	7·8	..	..	..
5	25 gm. of *Acacia catechu* heartwood, saw dust and 2 gm. of hexamine	do.	do.	26·45 gm.	2·08	2·8	4·2	4·5	Still in good condition in water.
6	25 gm. of *Terminalia chebula* bark powder 0·5 gm. hexamine 1 cc. glycerine	do.	do. ¼ hr.	..	..	..	..	..	Broken while removing from the mould.
7	25 gm. of *Terminalia chebula* bark powder 10% of lime (2·5 gm.)	do.	do. ½ hr.	26·22 gm.	11·8 (in 90 hrs.)	..	..	..	..
8	25 gm. of *Acacia catechu* bark powder 2 gm. of hexamine	do.	do.	25·24 gm.	5·4	8·9 (in 95 hrs.)	*Compression** :— 3136 lb./sq. in.		
9	12·5 gm. sal bark powder 12·5 gm. *Acacia catechu* heartwood powder 2 gm. hexamine 0·1 gm. sulphur 0·02 gm. NaOH (5 cc. N/10 NaOH)	Mixed thoroughly and put in the mould	Pressed in a Jack for ½ hour and heated	29·22 gm.	5·9 (in 46 hrs.)	6·5 (in 72 hrs.)	*Compression** :— 3991 lb./sq. in.		
10	20 gm. *Acacia catechu* heartwood powder 4 gm. urea 1·33 gm. paraformaldehyde	do.	do.	24·41 gm.	5	..	..	..	..

* In wet condition.

BOARDS

In these experiments the bark powder (usually of sal or *Acacia*) was mixed with paraformaldehyde or furfural, etc., and pressed at 160°C at a suitable pressure. In some tests, saw dust (mango) or (*Acacia* heartwood) was also added. In other's 1/32" toon (*Cedrela toona*) veneers were used as faces. Varying results were obtained indicating that more work is necessary for standardizing the product. In one experiment using 35 gm. of sal bark powder and 35 gm. of mango saw dust, 2 gm. hexamine, 11 gm. furfural-glycerol, mixing well and pressing them with 1/32" toon faces a board giving 11,500 lb./sq. in. in tensile strength and about 20,000 lb./sq. inches modulus of rupture, with a water absorption of 9% for 24 hours was obtained.

COMPREG BOARDS

Compregnated boards were made with either veneers of the heartwood of *Acacia catechu* alone or the same veneers alternated with veneers of toon (*Cedrela toona*). Alternate veneers were painted with formaldehyde or dusted with paraformaldehyde; sodium hydroxide was used as a catalyst. In other cases hexamine, furfural, etc., were also employed. The pack was pressed at 140°C at pressures varying from 1,000 to 2,000 lb./sq. in. Tensile strength values varying from 10,000 to 20,000 lb./sq. in. and static bending strength of 16,000 to 25,000 lb./sq. inches, were obtained. Glue ahdhesion was not entirely satisfactory in all cases. Considerable work is necessary to standardize the conditions.

SUMMARY AND CONCLUSIONS

Preliminary experiments indicate that building boards and moulding compositions can be developed from various tree barks containing tannins, a small quantity of paraformaldehyde or furfural, etc., being the only other material necessary.

Satisfactory moulding compositions can be made from bark powders mixed with paraformaldehyde, hexamine, etc.

Tannins in bark and wood appear suitable for the preparation of plywood adhesives.

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THE END OF MY FREEDOM

A Story told by a Captive Elephant

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SUMMARY

The narrative embodies the details constituting the "Pit Method" of capturing elephants as practised in Travancore-Cochin. Where the pits are usually dug and at what time of the year, how they are camouflaged and how the unwary elephant falls into it are all described as if the story is narrated by the elephant itself. The captives' experiences inside the pit and how it was noosed in, brought out of the pit and marched away to the kraal in spite of its incessant efforts to free itself are also described in the elephant's own words.

It was on the 14th May 1948 that I was entrapped and imprisoned. For the first time in my life I felt ashamed of my huge size and massive strength. Of what use are these large tusks and powerful trunk, great height and enormous girth if I should be outwitted everytime by the dexterity and detestable foulplay of these two-legged creatures called men ! Yet I admire their brain just as perhaps they do my brawn.

My first experience of the vagaries of man was early in December 1947 when a rumour was afloat that an elderly man named Chacko was roaming about the forests with a number of coolies and digging pits here and there. His actions were so secretive that my companions and I (we always travel in herds of young and old) did not know what this adventurous man was planning to do. A few days later came the news that my sister's son was missing. All that the broken-hearted mother could relate was that the previous night her little boy stumbled into a deep pit and early next morning men were there in large numbers and they chased her away with shouts and shots. They must have killed the poor boy and eaten him up !

Time, of course, is the best soother of sorrow and as days rolled by the burden of grief lessened and soon we became joyous once again. Summer was approaching, days were getting hotter, forest fire had begun to appear on the hill-tops, there was scarcity of water and we had perforce to undertake our annual 'migration' to the river and stream banks.

It was on a moonlit night that we stepped across a broad stream. The water was cool and refreshing. We had a hearty drink and an exhilarating bath, and after an hour or so of water sport we rolled back into the forest. We were so full of mirth and fun that we broke up company and in a playful spirit took to different paths which were so familiar to us during our incursions into this beauty spot. Not far from the stream bank I discovered a heap of fresh earth. I liked the smell of it, smeared it all over my body and rushed forward to meet my comrades. Dhup ! with a crashing noise I tumbled into a deep pit*.

For a moment I was stunned and did not know where I was ; but when I discovered that I had been inescapably entrapped in a deep pit the story of the mishap that occurred to my little nephew flashed across my mind and I lost my nerve.

I cursed my fate ; I cursed that crooked Chacko and his gang, for they were the people who dug this pit right on my usual path and yet concealed it from me. The mouth of the pit was covered with reeds and herbage and was so cleverly camouflaged with dry leaves and twigs commonly found in that part of the forest that none could suspect the hidden danger. Though

* The pits are circular with a diameter of 12 feet at the top and 9 feet at the bottom. The depth is 12 feet. They are dug either singly or in twos or threes in the form of ○ ○.
○

bent on mischief these men must have been innately kind for they had put inside the pit brushwood and leaves to a depth of about 4 feet and but for this cushion my bones would have been broken.

Yet I did not know what was awaiting me. I roared (trumpetted) aloud and listened for a while. I roared (trumpetted) louder still and listened sharper than ever. There were no signs of my companions ; they had all bolted away and I was left alone to an unknown fate.

With a mighty rush I gored the sides of the pit with my tusks and scooped out a good quantity of earth. (Fig. 1. Plate I). The sides of the pit were giving way little by little but I was too tired to continue the process for any length of time. Very soon it was day break and there emerged from somewhere two watchful men*. I gave out a shrill trumpet and the men ran away. But alas ! within an hour or so they came back in larger numbers. Strangely enough there were three elephants coming along with them and stranger than ever, there were human beings perched on the shoulders of these individuals of my own tribe. Two of them were huge tuskers and would you believe it, the third was a lady.

The men came on steadily and made all sorts of noises—apparently they were busy doing something I knew not what. I lifted up my head, propped my forelegs on the sides of my prison and bellowed out a loud trumpet. To my bewilderment the men were not afraid of my loud voice and one fellow brought up a huge tusker and made him stand near the pit, as if to monitor me. Though of my own tribe he was a monster in himself with such a massive head and such large tusks that I shuddered to look at him and remained quiet inside my little apartment. Just at that time one man came up near the pit and poured a bucket of water on my back. Though it tickled my vanity I welcomed this generous act because my back was sweltering with heat and the good fellow repeated this process three or four times at intervals.

I then heared the sound of axes and two or three trees crashing down. In less than a couple of hours the men had placed five or six huge logs across the mouth of the pit and thus blocked the only opening—exit or entrance of my little cell. [Fig. 2. Plate I]. I thought I was to be buried alive ; all my protests and prayers were in vain as the men were bent on mischief.

They brought a stout big rope (made of Sterculia bark) with a large safety noose at the end of it and slowly lowered it into the pit. With my trunk I pulled down the rope with one swish and trampled it under my foot. But the little rascals poked me with long sticks and when I moved from this side to that they pulled out the rope with great agility only to remake the noose and lower it again. Four times they tried and all the four times I pulled the rope down ; but the men persevered and I lost the game in the fifth round when the noose slipped past my trunk and fell round my neck. The men pulled at it vigourously and I pulled the opposite way not knowing I was helping them to tighten the noose around my neck. Thus for the first time in my life I wore an ornament ! But that was not all ; more was to follow. After another half an hour's struggle my right hind leg was noosed in a similar way. I thought next would be my foreleg, but to my surprise it was my neck again.

In the meanwhile others had collected large quantities of billets and brushwood which they began dropping, one by one, into the pit. But every one of these pieces I trampled under my foot and stood upon it thus raising myself steadily until my back was within the reach of the men standing over the logs who utilized the opportunity to securely fasten the nooses on my neck by means of smaller ropes. (Fig. 2. Plate I).

More billets and brushwood came in at a faster rate and then there was a glorious gesture. The logs were removed one by one and the wall of the pit on one side was broken into some extent. I could easily scramble out of the pit but I was afraid to do so because there stood on either side of the pit two ignominous members of my own tribe—the big lady and her monstrous

* Every morning watchers go out, in pairs, on an inspection of all the pits. If there are any 'falls' they atonce inform the Ranger who then arranges for out-pitting the animal and enkraaling it.

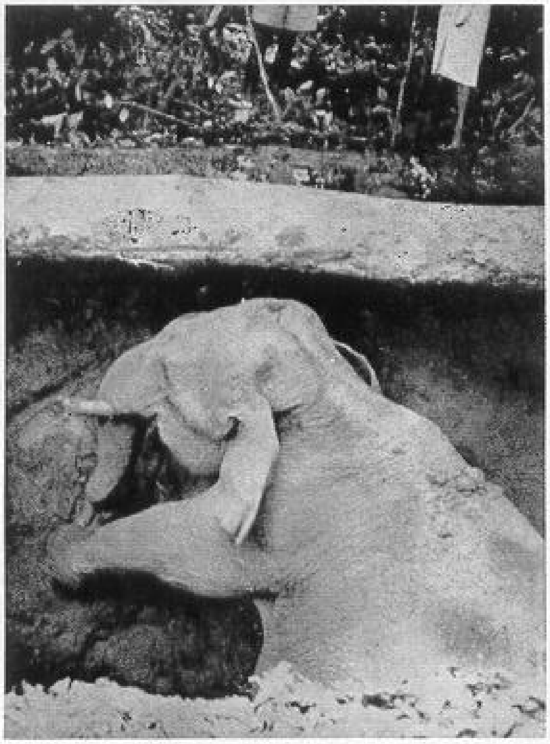

FIG. 1

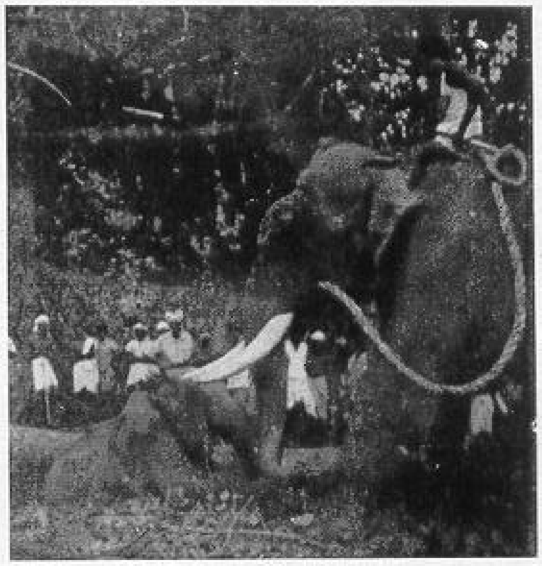

FIG. 3

FIG.

PLATE II

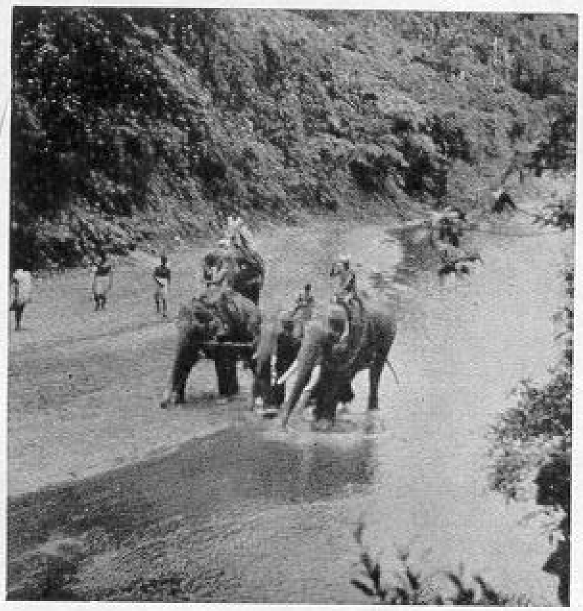

FIG. 4

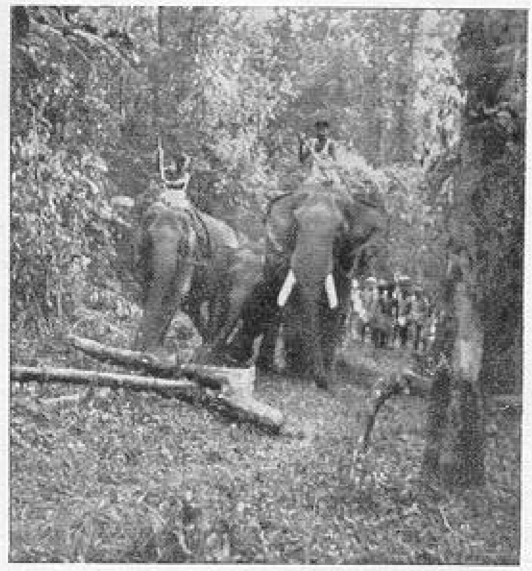

FIG. 5

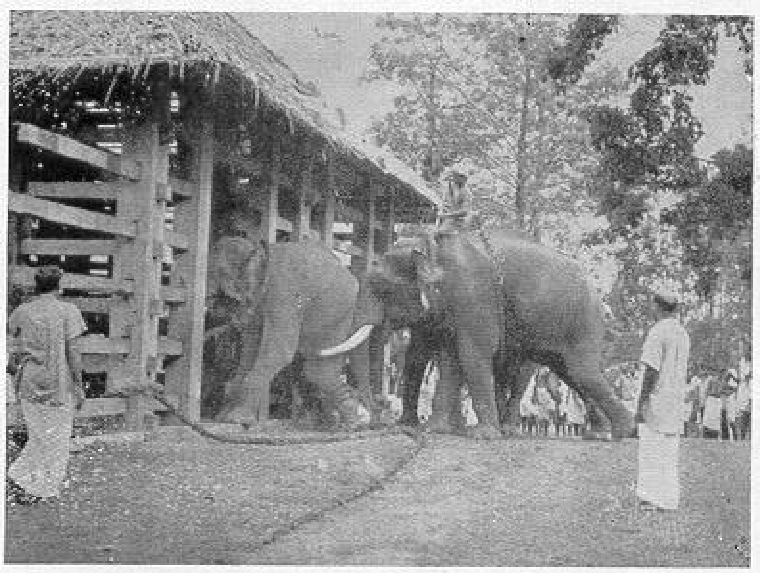

FIG. 6

brother—with their human masters perched on their shoulders. All the men had, by now, gathered behind the pit and were making all sorts of noises. Some of them poked me with sticks while others tickled me with brushwood.

All on a sudden I decided to have my last tug and make good my escape. I hastely scrambled out of the pit [Fig. 3. Plate I] and rushed forward—but not for long. The men had tied the rope on my hind leg to a tree behind and I was held up. At the same time the elephants on either side of the pit—'decoys' men called them—moved up quickly and took up their positions close beside me. Each of them picked up a rope noosed round my neck and held it firmly between their teeth and so close to my neck that I felt absolutely helpless. All these happened in the twinkling of an eye. It was really a tense moment of intense activity that I, in my confused state of mind, could not do much to free myself. Moreover the big tusker on my right was a rude fellow and I was mortally afraid of him. But the presence of the grand lady on my left put me at ease though she too was equally strong and firm. The hind rope was then released from the tree and the third decoy took that up.

The signal for the march was given by somebody in Khaki who appeared to be the leader of this herd of men. The indignity of bondage hung on me and with a heavy heart I moved on. I could not turn this side or that nor could I go forward at my own pace. I was held firmly by the two stalwarts on either side who led me away under the orders of their human masters. [Fig. 4. Plate II]. At every path I knew and at every track with whose course I was familiar I struggled hard to free myself but my 'trained' kinsmen held me fast [Fig. 5. Plate II]. What a remarkable sense of duty they had ; what abject loyalty to their foreign masters !

Soon I was out of my own territory for we had crossed the forest boundary and had entered the fields. In less than half an hour I was brought before a large wooden enclosure which they called 'cage' or 'kraal'. This elephant cage had six compartments and in the farthest of them I saw my little nephew staring at me with tears in his eyes. It raised a tumult of feeling in my mind ; after all the men have not eaten him up !

The entrance to the compartment facing me was open. The decoys now moved aside but the men had taken my ropes around the farther pillers of the kraal and were holding on to them so that the only way I could move was to step into the kraal. Just then [Fig. 6. Plate II], the big tusker pushed me forward into the kraal and before I knew what was happening the men had closed the entrance by sliding the bars in position. The ropes around my neck and leg were then cut and removed, but alas ! I was not freed but was fated to be trained as a slave of my captors.

LIST OF ILLUSTRATIONS

PLATE I

FIG. 1.—Wild elephant inside the pit. Note the fore-legs propped up against the sides of the pit and the elephant goring the side with its tusks.

FIG. 2.—Logs laid across the mouth of the pit and the men on the top examining and fastening the nooses around the neck of the elephant.

FIG. 3.—Captive elephant scrambling out of the pit. Note the decoy on the right with rope already between its teeth.

PLATE II

FIG. 4.—Captive elephant being marched along a stream bed. Captive is in the middle and the two decoys on either side.

FIG. 5.—Captive elephant being marched along a forest path.

FIG. 6.—Captive elephant being enkraaled. The ropes of the neck having been tied to the pillars of the kraal the decoy is gently pushing the captive into the cell. Note the sliding bars of the entrance.

THE VARIATION OF SOME MECHANICAL PROPERTIES OF WOOD WITH TIME, NOTCHES AND TEMPERATURE

Prof. Dr.-Ing. F. Kollmann, President of the German Federal Institute of Forestry and Forest Utilization Research and Professor, University of Hamburg, who has come to the Forest Research Institute, Dehra Dun as an F.A.O. Forestry Expert under the expanded technical assistance programme delivered a series of three special lectures on the above subject at the Forest Research Institute on 3rd, 5th and 7th September, 1951.

Tracing the development of testing of materials during the past several decades Prof. Kollmann pointed out that usual tests at atmospheric conditions and at speeds varying from a total time of a few seconds to some minutes sufficed till Woehler introduced fatigue in the consideration of mechanics of materials. In the normal static tests as practised in various countries the speed of loading varies from 15 Kg/cm.^{2} min to 600 Kg/cm.^{2} min, depending on the type of test and the country. During the last 30 years the influence of time on the mechanical properties of wood have been tested notably by Markwardt (U.S.A.), Perem (Sweden), Ghelmeziu, Graf, Roth, Riechers and Kollmann (Germany). The duration of testing varied from about a fraction of a second to 100 minutes in the static tests and over a year in the creep tests. These experiments clearly showed that while in the medium speeds of loading used by Kollmann the strength was approximately constant it went down considerably with long duration and increased with high speeds. While creep tests require very little equipment and static tests can be carried out with normal equipment available in testing laboratories, the investigation of impact tests requires refined technique. After briefly describing the 'krokodil' developed by Breuil in France Prof. Kollmann described the piezo-electric oscillographic technique used by him. These experiments showed that in the impact tests where the bearing reaction was measured with the help of a piezo-electric indicator, the maximum bearing reaction characteristic of the dynamic stress was attained in a time of about 10^{-4} second and the entire dynamic breaking process lasted for a brittle ash piece 0·002 second and for a very tough ash piece 0·012 second, i.e., the tougher the piece the more is the time necessary for rupture. Consideration of the data of the investigators mentioned above leads to the conclusion that nothing stands in the way of extrapolating Markwardt's curve showing the relation between fibre stress at elastic limit in static bending and modulus of rupture and duration of stress to 10^{-4} second. The extrapolated curve for a period of $8 \cdot 10^{-10}$ second shows that the bending stress should be higher by about 100% than with the normal bending strength. Prof. Kollmann also briefly drew attention to alternating stress tests and illustrated the relation between fatigue and creep tests by appropriate fatigue strength diagrams from his own work. The influence of time on the various strength properties of wood can be summarized in the following table :

Relative Ultimate Stress of Wood with Different Types of Stressing

Type of experiment	Tension or compression	Bending
Impact (0·0001 Sec.)	..	1·3 ....1·75
Bending (static)	1	1
Creep test	0·60	0·60....0·70
Fatigue (tension)	0·30	0·22....0·38
Alternating (tension-compression)	0·15	

The above table shows clearly how necessary it is to consider time as a co-ordinate in the mechanics of materials and Prof. Kollmann emphasized the priciciple that any ultimate stress has a real meaning only when the duration of (action of) the load leading to failure is known and any differentiation of dynamic and static tests is no longer justifiable.

In order to find an explanation for the time factor in the strength of wood Prof. Kollmann briefly discussed the elasticity and plasticity of various types of high polymers. Wood and cellulose belong to elastic—plastic materials and the characteristic diagram of the loading-unloading cycles combined with a hysteresis-loop and, therefore, the energy loss for such substances was briefly discussed. The energy losses increase with each cycle at the end causing the break. The properties of some materials may change stepwise finally leading to loading and unloading cycles which are identical, i.e., the previously plastic material has been changed to an elastic one. Wood with its combination of crystalline elastic regions and plastic amorphous areas in its tissues can be represented in the rheological sense by the Maxwell unit, i.e., a spring in series with a dashpot. The parallel circuit of elastic and viscous elements can also find application in the study of the rheological behaviour of wood as a consequence of the highly crystallized secondary wall of the fibre and the amorphous middle lamella. This is evident from creep and after effect phenomena. The plasticity of wood as pointed out by G. Ivanov is probably due to the gliding of the micelles. This gliding is intensified by the rise of temperature which lowers the biscosity of water or melts some of the wood constituents. While generally it is regarded that these act unfavourably (e.g., swelling of structural parts) it is not so well known that they can also find application in the better utilization of wood, e.g., moulding, etc.

The influence of form, when it leads to the development of local stresses and may be associated with stress peaks can be summarized under the term 'notch effects'. Such effects arise through sudden changes of form (sharp edges), injuries, holes, etc. As wood in comparison to metals has a very small total extension and especially in tensile tests of short duration there is no plastic deformation it can be concluded that stress peaks due to notches cannot be smoothed out and notched pieces must have an essentially lower strength than unnotched ones. After a brief general discussion on notches Prof. Kollmann dealt with the effect of notches in wood and wood based materials when subjected to tensile, compression, bending and dynamic stresses. Improved wood behaved somewhat less favourably than solid wood. The theoretical reason for the higher notch sensitivity of improved wood is due to the selection, homogeneity and improvement of their mechanical properties, which *a priori* must lead to relatively higher peak stresses than in solid woods with their wide structural variations, internal failures and lower strengths. In case of solid wood one can speak of a structural 'internal notch effect', in contrast to which external notches lose in significance. In tensile tests on solid and laminated pine the notch sensitivity with solid wood was 1·3 to 1·19 while with laminated wood it was 1·91 to 1·43. The form of the notch was without significance. The notch depth ratio and the thickness of the specimens were found to have an influence. As in isotropic materials stress peaks are situated in the notch apex.

In compression the failure is characterized by a fibrous fracture at the side end of the hole due to longitudinal stresses and cleavage fractures at the upper edge of the hole due to tension perpendicular to the grain. Fibre buckling failure occurs only when $d/b \leqq 0 \cdot 5$ and cleavage failure when $d/b \geqq 0 \cdot 5$. An interesting fact is that accumulation of material in glued parts shows notch effects. Based on the fine structure of wood it can be shown that notch sensitivity in tension should be higher than in compression. The tensile stresses are mainly taken up by the highly elastic chain-line crystalline regions while in compression the

amorphous 'defective areas' in the fibres and the lignin rich middle lamella behave as a plastic.

In bending, since notches are always situated on the lower side, specimens behave more like those in tension. The notched specimens break at much lower deflections, which can be explained by the simultaneous action of plasticity and elasticity. Frequently cleavage of the specimens takes place with laminated wood. The separated notch free piece then behaves like a normal piece thus masking the effect of the depth of the notch.

Notch stresses are of special scientific importance in dynamic experiments. The notch sensitivity is specially high in impact tests. In contrast to solid wood, in improved woods a considerable decrease in toughness is caused by the brittle resin. It is, therefore, necessary to so regulate the pressing operation that this property is not adversely affected. Addition of a plasticiser will also help. Due to the large structural variations in wood it is better to use large specimens for impact tests. Due to the large variations caused by the deformation processes between the stiff summer wood and the yielding spring wood the notch effect now lies in the summer wood and now in the spring wood. So impact tests should be done in the tangential direction. With the depth of notch the impact work decreases. The influence of moisture on solid wood deserves further investigation. With laminated wood at 0–20% moisture content it has very little significance. Notch sensitivity is very closely connected with the time factor. In fatigue tests surface injuries with a large radius (e.g., 10 mm.) are without influence ; on the other hand a sharp notch and a hole with 2 mm. lower the number of stress cycles but not to a very great extent.

Finally the important effect of temperature was considered by Prof. Kollmann. Modern aircraft can often be subjected to extreme changes of temperature of nearly 150° C in a few minutes. After briefly discussing the influence of temperature on cohesion based on molecular considerations (potential theory) he discussed the influence of temperature on the various mechanical properties of wood. The pioneering and fundamental work in this field is due to Prof. Kollmann. Work done by Thunell and the most recent and extensive work of Sulzberger were also considered in this connection. The Modulus of elasticity decreases with temperature and in the temperature range 20° to 60° C the coefficient is 0·42 to 0·75% ° C. The effect is more pronounced with increased moisture content. In tensile tests in addition to thermal oscillations water of imbibition can reduce the strength considerably due to decreased viscosity through improved gliding of the micelles.

The type of resin and conditions of manufacture influence the effect of temperature on the properties of compreg.

As the tensile strength across the fibre lies mainly in the side cementing of the fibres other relations exist here ; *viz.*, on the variation of the shearing strength of the middle lamella which act as glue joints. From the analogy of the behaviour of glue joints Prof. Kollmann concludes that the strength of wood across the grain at low moisture contents should be little dependent on temperature while at higher moisture contents it should be highly influenced by it. This is confirmed by the experiments of Greenhill. In the high frequency field Prof. Kollmann found a linear relation.

The theoretical prediction of a regular and pronounced dependence of compressive strength on temperature has been confirmed by the experiments of Kollmann and Sulzberger. The temperature coefficients as a function of density varies from 3·1 to 7·9. The coefficient is a maximum at 11% moisture content, varies with moisture content as a quadratic function, and does not vary with species. The compressive strength of wood at $-20°$ C over the entire hygroscopic range is considerably higher than at 0° C, this being especially high with water

saturated wood. This is explained by ice lattice formation in the wood. With frozen wood two maxima are noticed one at the boundary between surface absorption and capillary condensation and the other at a higher moisture content at which the ice lattice on melting with compressive loading gives a lower strength. In bending experiments with water saturated specimens and heating in the high frequency field a marked plasticisation of wood was noticed. A thermal after effect and hysteresis were observed. Above a critical temperature of 70° C the modulus of elasticity on cooling is lower than the initial value. There are reasons to believe that irreversible changes in the cell wall take place. The significance of these findings in the moulding of wood and other technical processes may be emphasized. The effect of temperature on the impact strength varies with species and requires more careful investigation.

In conclusion it was pointed out by Prof. Kollmann that the influence of time, temperature and notches can all be expected from the elasticity, plasticity and structure of wood. The lectures brought home the fact that for a deeper understanding of the properties of wood the modern tools of the physicist the engineer, the chemist and the colloid scientist should be employed in increasing measure.

D. NARAYANAMURTI.

A SHORT INTERIM NOTE ON *TEMPORARY* PRESERVATIVE MEASURES TO BE ADOPTED IN THE CASE OF TIMBERS AMENABLE TO DETERIORATION DURING *TRANSIT AND STORAGE*

BY DR. A. PURUSHOTHAM

Officer in Charge, Wood Preservation Branch, Forest Research Institute, P.O. New Forest, Dehra Dun, U.P.

TREATMENT OF TIMBERS IN GENERAL

The sapwood of all species of timbers and the heartwood of a majority of them are liable to deterioration through decay by fungi and attack by insects (white-ants and borers); this is particularly so when the timber is green and the weather is humid and hot. The loss due to such deterioration runs into several lacs of cubic feet of timber each year, and if no preventive steps are taken, it will react adversely on our Forest resources. It is of course best, to get the trees felled during the autumn season and then get the timber quickly converted and kiln seasoned, when the attack will be considerably reduced. But, it is not possible to do so for want of saw-mills and seasoning kilns on the spot. Under these circumstances, it is advisable to give *temporary* protection by suitable chemical treatment. While there are quite a large number of compositions that may be tried for the purposes, the choice is, in practice, limited to one or two on grounds of (1) ease of procurement (2) ease of transport (3) ease of application and (4) low cost. Experiments are under way to test the efficacy of various compositions but an interim recommendation can, however, be made as detailed in Table I. For satisfactory protection under service conditions, these timbers will have to be given a further thorough preservative treatment.

TREATMENT OF BAMBOOS

The surface of bundles of freshly felled bamboos may be sprayed with the preservative after the branches and the crown are removed; if this is not possible then the ends and the knots may at least be thoroughly painted with the preservative. As in the case of timber, a thorough preservative treatment needs to be given in this case also before use for obtaining satisfactory results.

TREATMENT OF TIMBERS AGAINST SAP-STAIN[1]

There is also another type of deterioration often met with in species[2] like *Bombax malabaricum, Ailanthus* spp., *Moringa pterygosperma, Erythrina* spp., *Boswellia serrata, Trewia nudiflora, Anthocephalus cadamba, Sterculia campanulata, Veteria indica,* etc. The logs and planks when freshly cut are attacked by fungi belonging to the species *Ceratostemella, Graphium,* etc., which live mainly on the reserve food materials and not on the cell walls. Therefore, they do not affect materially the strength of timber except in toughness, but cause such discoloration (blue stain) that detract from the appearance of the timber. Naturally such stained timber is degraded and fetches low market value. Further, in industries like air-craft, paper, etc., where toughness and colour cannot be overlooked, such stained timbers are not acceptable. To prevent this defect, it is best to treat the logs and freshly sawn planks with 2% Sodium pentachloro-phenate. Such treated timber must be kept under cover since the preservative is liable to be washed out by rain. If this chemical is not available in the market, one of the first two preservatives mentioned in Table I may be used.

If the risk of fungal decay is negligible during transit, as is the case with certain hard wood logs and bamboos, temporary protection from insect (borers) attack may be secured by spraying the logs with 1–2% Gammexane[3] in water dispersion. Again, since the compound is easily washed away during rains such treated logs should be kept under cover ; if this is not possible, then one of the first two preservatives mentioned in Table I may be used.

For proper treatment with any of the preservatives mentioned in this note, the green log must be thoroughly debarked, particularly the thin skin closely attached to the sapwood, immediately at any rate within 24 hours of felling the tree, and then sprayed thoroughly with the preservative.

REFERENCES

1. 'Stains of Sapwood and Sapwood Products', by T. C. Scheffer and R. M. Lindgren, U.S. Department of Agriculture, Technical Bulletin No. 714, March. 1940.
2. 'Note on Sap Stain and its Prevention', by D. Narayanamurti and J. N. Pande. I.F. Leaflet No. 68, 1944.
3. New South Wales Forestry Commission, Division of Wood Technology. Project No. F.E. 3, by P. Hadlington, October, 1950.

TABLE I

Serial No.	Preservative and its composition by weight	Concentration of preservative in water %	Quantity of preservative to be dissolved in a 4 gallon tin	Quantity and cost of preservative required for treatment of: 1,000 B.G. Sleepers — Quantity of solution	1,000 B.G. Sleepers — Cost of chemicals (Rs. a. p.)	1,000 sq. ft. of timber surface — Quantity of solution	1,000 sq. ft. of timber surface — Cost of chemicals (Rs. a. p.)	REMARKS
1	*ASCU-boric* Boric acid ..1·5 parts Copper sulphate ..3·0 parts Sodium dichromate ..4·0 parts	6	2·4 lbs. (2 lbs. 6½ ozs.)	200 gal. (dissolve 120 lbs. dry salt in 200 gal. of water)	157 8 0	10 gal. (dissolve 6 lbs. dry salt in 10 gal. of water)	7 14 0	The preservative may be applied by dipping the timber in it for 5 minutes or brush coating the surface of the timber with it twice, the second after the first dries, or spraying the timber with it all over quite thoroughly. In the case of sleepers they may be stacked in the ONE in NINE way and the planks with crossers in between. In either case the timber must be stacked in skids at least 18″ high from the ground and erected over masonry or well treated timber pillars. The yard must be kept hygenically clean and periodical inspection of the stacks must be carried out, and the treatment repeated if found necessary after a lapse of *three months*. Attack of borers is recognized by the appearance of fine powder of timber on the surface. Badly attacked materials should be disposed off.
2	Boric acid ..1 part Zinc chloride ..3 parts Sodium dichromate ..4 parts	8	3·2 lbs. (3 lbs. 3¼ ozs.)	200 gal. (dissolve 160 lbs. dry salt in 200 gal. of water)	150 0 0	10 gal. (dissolve 8 lbs. dry salt in 10 gal. of water)	7 8 0	
3	Gammexane	1	0·4 lb. or 6½ ozs.	200 gal. (dissolve 20 lbs. chemical in 200 gal of water)	35 0 0	10 gal. (dissolve 1 lb. chemical in 10 gal. of water)	1 12 0	

(1) When dealing with large quantities of timber, the spraying method is recommended.

(2) While the preservative is being sprayed, it is best to provide the workers with a mask to protect their nose and eyes.

(3) The above prices are calculated at the current market rates.

(4) Any one of the first two methods can be adopted against decay by fungi and attack by borers and the third only against attack by borers.

(5) In the case of logs, it is best to debark them thoroughly and then spray the surface lavishly with the preservative. A log 14 feet long and of 2 feet diameter exposes roughly 100 square feet of timber surface.

(6) The timbers immediately after preservative treatment must be protected against rain and water for at least one week.

The preservative ASCU-boric is patented by Dr. S. Kamesam. Either on the material as such can be got from M/s Weld-Wood Roof & Bridge Structures, 4, Miller Road, Bangalore, or may be compounded by purchasing the components from the market. The following firms deal with the chemicals mentioned in the Table.

1. M/s Bengal Chemical & Pharmaceutical Works Ltd.,
   94, Chittaranjan Avenue,
   Calcutta.

2. M/s Premier Chromate & Chemical Works Ltd.,
   402, Cadell Road,
   Bombay 28.

3. M/s Golden Chemicals Ltd.,
   Vile Parle,
   Bombay 24.

4. M/s Tropical Scientific Industries,
   B/2/110, Bhadaini,
   Benares.

5. M/s Monsanto Chemical of India Ltd.,
   138, Mahatma Gandhi Road,
   Bombay 1.

6. M/s Imperial Chemical Industries (India) Ltd.,
   Madras (Specially Sodium pentachlorophenate and Gemmaxene P 520).

Sprayers can be had from M/s The General Export Company, 1 British Indian Street, Calcutta 1. Their "KNAPSACK SPRAYER" 4 gallons capacity costing Rs. 85 is quite suitable for the purpose.

STATEMENT OF ACCOUNTS OF THE *INDIAN FORESTER* FOR THE YEAR 1950

Item No.	RECEIPTS	Amount	Amount
		Rs. A. P.	Rs. A. P.
1	Opening balance as on 1-1-50 :—		
	(*i*) Face value of investments in custody with the Allahabad Bank Ltd., Dehra Dun as per details :		
	3% conversion Loan 1946 ..	18,300 0 0	
	Stock Certificates of 1946 ..	1,400 0 0	
	3% 2nd Victory Loan, 1959/61	3,900 0 0	
	3% F.D. Loan, 1970/75 ..	6,000 0 0	
	P.O. 5-year Cash Certificates ..	10,000 0 0	
	P.O. 10-year Defence Saving Certificates ..	2,500 0 0	42,100 0 0
	(*ii*) Cash with the Allahabad Bank Ltd., Dehra Dun ..		3,644 2 3
	(*iii*) Cash in hand		105 4 6
2	Subscriptions		16,223 15 5
3	Casual sale of back issues of the "Indian Forester"		137 8 0
4	Advertisements		257 11 0
5	Interest on loans and deposits ..		984 4 0
6	Reprints of articles published in the "Indian Forester"		368 3 0
7	Miscellaneous receipts		..
	TOTAL .. Rs.		63,821 0 2

Item No.	EXPENDITURE	Amount	Amount
		Rs. A. P.	Rs. A. P.
1	Establishment charges		1,411 0 3
2	Allowances and honoraria ..		..
3	Printing charges of the "Indian Forester"		5,305 7 0
4	Cost of paper		
	(*i*) for printing ..	285 0 0	
	(*ii*) For illustration, etc.	206 9 0	491 9 0
5	Cost of blocks		583 0 0
6	Stationery		5 7 0
7	Postage and Telegrams		733 9 6
8	Bank's commission, etc.		32 8 0
9	Income-Tax		243 3 0
10	Cost of store articles, their maintenance and repairs		2 14 0
11	Miscellaneous expenditure ..		80 8 6
			8,889 2 3
12	Balance as on 31-12-50 carried over :		
	(*i*) Face value of investments in custody with the Allahabad Bank Ltd., Dehra Dun :—		
	3% conversion Loan, 1946 ..	18,300 0 0	
	Stock Certificates of 1946 ..	1,400 0 0	
	3% 2nd Victory Loan, 1959/61 ..	3,900 0 0	
	3% F.D. Loan, 1970/75 ..	6,000 0 0	
	P.O. 5-year Cash Certificates ..	10,000 0 0	
	P.O. 10-year Defence Savings Certificates ..	2,500 0 0	42,100 0 0
	(*ii*) Cash with the Allahabad Bank Ltd.—		
	Amount as per Pass Book ..	8,415 1 8	
	Less cheques issue in Dec. '50 but cashed in January 1951 ..	2,105 0 0	6,310 1 8
	(*iii*) Cheques in hand not deposited into the Bank during 1950 as per details in the attached list		3,834 12 0
	(*iv*) Cash in hand		2,521 11 3
13	Deficit during the year		165 5 0*
	TOTAL .. Rs.		63,821 0 2

* A sum of Rs. 7,239-6-8, being the cost of printing the 1950 issues of the journal was actually paid by cheque No. 057246—23-1-51, to the Director, Geodetic Survey of India. So, the actual loss for the year 1950 is increased by the above amount to Rs. 7,404-11-8.

(SD.). V. S. KRISHNASWAMY, *Honorary Editor*, 31-8-51.

(SD.). M. D. CHATURVEDI, *Chairman, Board of Management, "Indian Forester"*, 7-9-51.

(SD.). T. S. RAWAT, *Auditor*, 25-8-51.

ROTATIONAL LOPPING OF EUCALYPTUS IN THE NILGIRIS

BY M. D. CHATURVEDI, I.F.S.
Inspector-General of Forests

SUMMARY

Experience gained in the Saharanpur *Siwaliks* and nearer home in the Nilgiris themselves in the privately owned estates, suggests the adoption of rotational lopping of the State plantations of Eucalyptus to support the cottage industry producing Eucalyptus oil. Retention of 1/5th of the crown at the top at the time of lopping and a rest of full 4 growing seasons after each lop is to be rigidly enforced. In addition to making India self-sufficient in respect of Eucalyptus oil, the scheme will yield an additional annual income of Rs. 50,000 and provide means of livelihood to the local population during the winter season when it has little to do.

Ootacamund represents a British enterprise in the Nilgiris like most hill stations do in India. While the settlement dates back to 1820, the towns of Ooty, Wellington and Coonor were developed some time between 1825 and 1835. For the ever-increasing population, the indigenous evergreen sholas could have been scarcely expected to meet the needs of firewood in these hills. *Eucalyptus globulus* and *Acacia dealbata* were introduced, therefore, as a source of fast growing and cheap fuel in 1843. Regular Eucalyptus plantations, however, came to be formed from 1856 onwards. In adition to yielding cheap fuel, the Eucalyptus plantations of the Nilgiris yield about 30,000 pounds of oil valued at about 1·25 lakhs of rupees. While a large number of the species of Eucalyptus have been tried, of recent years attention has come to be focussed in the main on *globulus*, *eugenioides*, and *paniculata*. Of these, *Eucalyptus globulus* is the most favoured species.

2. In accordance with the object of management, Eucalyptus is at present utilized in the main to meet the fuel requirements of Ooty and its environments. In the adjoining estates where Eucalyptus has been freely introduced, one comes up against large trees being sawn up into planks also.

3. Eucalyptus leaves yield a valuable oil. One comes up against country stills, set up here and there, more particularly on private estates. In these privately owned plantations, trees are stripped naked, with the exception of a tuft of leaves at the top, in alternate years without any apparent damage. The private owner has given the lead in the matter and shown both courage and imagination in embarking on this venture. Conservative, as Forest Officers are in their outlook, they have refrained from taking any risks in the matter beyond permitting the lopping of trees immediately before they are felled.

4. In this connection the experience gained in the Saharanpur Siwaliks (U.P.) might provide a useful pointer. The hypothesis, that deciduous trees in any case begin to discard their leaves with the onset of the winter season, when all growth progressively comes to a standstill, led to the belief held by Bhola and myself that no great harm could result if lopping is resorted to in anticipation of the leaf-fall in the cold weather, to provide leaf-fodder for *Gujars'* buffaloes. To ensure against any possible damage to the growth of trees a rest period of 4 (and later 3) clear growing seasons was provided. A carefully drawn up rotational lopping scheme was introduced in the *Siwaliks* in the thirties, which has provided leaf-fodder for as many as a thousand buffaloes during the most difficult period of the year, viz., winter when grasses turn brown and inedible. Periodic checks of the tree-growth subjected to the rotational lopping during the last 20 years have hitherto revealed no significant damage to the crop. Quite apart from the fact that these leaves, which would have been shed in any

case, adding to the inflammability of the locality, yield a handsome revenue in the shape of grazing dues, they constitute the mainstay of the supply of milk and *ghee* to the town of Dehra Dun, not to mention the source of livelihood they provide for the *Gujars*. The practice established in the *Siwaliks* has its sanction not in any scientific experiments, elaborate statistical analysis and calculations of significant variation, but in the hard school of experience extending over a period of 20 years.

5. It is difficult to foresee why Eucalyptus when subjected to rotational lopping would behave in any way different to the miscellaneous deciduous species growing on the slopes of the *Siwaliks*. One might argue that Eucalyptus is not in the strict sense of the term deciduous, that it does not shed all its leaves during the cold weather, and that it does retain some of its leaves to carry on until the next spring. Against this, one might remember that it is proposed to retain 1/5th of crown at the top which incidentally has the newest leaves, and that the lopping shock, if any, caused to the tree is to be followed by rest during the ensuing four growing seasons.

6. Considered in its briefest outline, the proposed scheme is best illustrated by the following example :—

Year of origin (coppice)—1930—Rotation 20 years

Lop during Nov.-Dec.	Rest for the growing seasons of
	1931 ; 1932 ; 1933 ; 1934
1934	
	1935 ; 1936 ; 1937 ; 1938
1938	
	1939 ; 1940 ; 1941 ; 1942
1942	
	1943 ; 1944 ; 1945 ; 1946
1946	
	1947 ; 1948 ; 1949 ; 1950
666 1950*	

* Fell after lopping early during 1950.

The above illustrates the pattern of what may be tried in the first instance and modified in due course in the light of experience gained. The rest period provided is for 4 full growing seasons. In the case of the plantations raised from seed, the first lopping may be omitted. Each lot put up for sale must have well-defined boundaries. The condition that the 1/5th of the crown at the top will not be lopped should be rigidly enforced.

7. The introduction of the rotational lopping in these plantations is estimated to yield a revenue of about Rs. 250 per acre at current rates. Allowing for the retention of 1/5th of the leaves, the income may be reduced to Rs. 200 per acre. In addition, it bids fair to the establishment of a flourishing cottage industry, finding employment for the local population during the winter season when it is more or less idle. Factory production is, therefore, not recommended except perhaps at Kodaikanal where there is no local demand for Eucalyptus leaves. It will go a long way in reducing the imports of Eucalyptus oil to this country which in 1949–50 amounted to worth Rs. 90,000. What is more, there is no reason why India should not build up a foreign market for this commodity.

8. The importance of scientific experimentation to determine the actual damage caused by rotational lopping to the growth of these plantations is not denied and should be undertaken at once. In the meanwhile, the experience gained in the Saharanpur *Siwaliks*, and next door in the privately owned estates where Eucalyptus is freely lopped in alternate years, point to an early adoption of rotational lopping in the Eucalyptus plantations in the Nilgiris. After all, Eucalyptus is being raised for fuel in the Nilgiris and 5 loppings during the life of a plantation are not likely to retard the growth of trees significantly. At worst, the rotation may have to be increased by one year. At current rates these loppings would fetch Rs. 1,000 (Rs. 200 per lopping) per acre, against the sale price of the final crop which is not likely to exceed Rs. 750 per acre. These figures speak for themselves. The value of the yield from leaves, it will be seen, is about 33% higher than that from firewood. The total area of the State plantations is 1,776 acres, the income from leaves alone should amount to about Rs. 88,000 per annum. Allowing for unforeseen contingencies and a certain amount of income which already accrues from the lopping of trees before they are felled over, it will be safe to assume an income of additional Rs. 50,000 per annum from this source.

FORESTS, CATCHMENT AREAS AND WATER SUPPLIES

BY PROFESSOR E. P. STEBBING, M.A.

Fellow of the Linnean Society, Fellow of the Royal Geographical Society, Fellow of the Royal Society of Edinburgh. Honorary Member of the Society of American Foresters, formerly of the Indian Forest Service, now Head of the Department of Forestry, University of Edinburgh

PART II

(*Continued from* The Indian Forester, *November 1951, page 698*)

MIDDLE EAST

EGYPT

It is of course a commonly accepted fact that the Nile is the river of Egypt, running for the most part between a narrow ribbon of cultivation, slightly varying in breadth, the variation being usually on the one side more than the other. But this is only putting the position in very simple terms. Otherwise it is commonly accepted that there are no other rivers in Egypt.

This is not, however, quite the whole story, especially in the case of the Nile, for the river of course, perhaps it would be better to say the two chief rivers, the Blue and White Nile join at Khartoum and thereafter form the river Nile ; they do not rise in Egypt nor is that the case with any of their tributaries.

In connection with the enquiry undertaken in this paper, the main sources of interest and importance are of course, in the two great rivers the Blue and White Nile and in their tributaries and in the catchment areas of these rivers.

To give one instance, the Atbara river rises in the northern part of the Ethiopian plateau and is 800 miles long before it flows into the Nile. There appears to be little doubt that the Atbara river is drying up to some extent since only a few miles from the junction with the Nile in the hot weather season the main flow of the river is constricted to one side and there are even pools in the river bed where once there must have been a main stream flowing all the year round.

From this alone it is apparent that it is not only Egypt which is primarily interested in the Nile but the whole of the Sudan as well ; and that Abyssinia and to some extent Uganda have some responsibility for the catchment areas.

Since Egypt could not be omitted from the enquiry, the Royal Egyptian Embassy was addressed in the matter and they, by means of Mr. G. A. Fetough, Agricultural Attache, were kind enough to send me the following :—

"1. The only river in Egypt is the Nile. The length of the river from its source in Central Africa to the Mediterranean where it flows out 4,150 miles.

2. The names and lengths of the chief tributaries of the Nile are :—

(*a*) *The Sobat* which rises in the mountains of south-west Abyssinia. This is the first great eastern affluent of the Nile.

(*b*) *The Blue Nile* length about 850 miles. The Blue Nile rises in the mountains of Abyssinia and flowing northwards enters Lake Tsana from where it issues to join the main river.

(c) Two hundred miles below the junction of the Blue Nile with the main river the Nile is joined by the last of its eastern tributary streams, *the Abara,* 800 miles long.

(d) There are no tributaries of the Nile in Egypt, at the beginning of the Delta the Nile merely separates into two channels, the Rosetta and the Damietta, which flow into the Mediterranean. Both are about the same length—146 miles.

3, 4, 5. There have never been natural forests of any kind in Egypt except in the pre-historic days. The forests exist on either bank of the Nile in some parts of the Southern Anglo-Egyptian Sudan".

I do not know that his last statement is in keeping with the early historical records of Egypt in the days of the Pharoahs, for it would appear probable that there were in fact more forests on the Nile in those days than has been the case for many centuries now.

The Nile has been discussed under the Sudan p. 213 ante.

ISRAEL

Mr. A. Y. Goor, Conservator of Forests, kindly gave me some interesting data in answer to my questionnaire. The most significant part about this information is that the amount of forest standing on the catchment areas of the rivers has been reduced to very small amounts, while those catchment areas are also under shifting cultivation and grazing. The following is the report sent to me.

THE CHIEF RIVERS IN ISRAEL AND THEIR TRIBUTARIES

The drainage systems in Israel are mostly in two main directions, viz., westerly into the Mediterranean and easterly into the Jordan–Dead Sea trough. The most important rivers from north to south and their tributaries are :

Easterly Drainage :

The deep cut dividing Israel from Syria in the North and from Trans-Jordan in the South is called the Jordan valley. The source of the Jordan is connected with Mount Hermon in Lebanon and is fed by three main rivers :

(1) HASBANI .. Length from source in Lebanon to Israel frontier 14 miles. Length from frontier to mouth where it flows into the Jordan—5 miles, giving a total of 19 miles.

(2) LIDANI .. Length 6 miles from source in Israel to mouth where it flows into the Jordan.

(3) BANIAS .. Length from source in Syria to Israel frontier 1 mile. Length from frontier to mouth where it flows into the Jordan 7 miles. Total 8 miles.

There are no tributaries to these rivers.

(4) JORDAN .. The internal lakes and seas divide this river into 3 distinct regions :

(i) From source (i.e., the meeting point of the above three rivers) to lake Hulah—9 miles.

(ii) From Lake Hulah to the sea of Galilee—11 miles.

(iii) From the sea of Galilee to the Dead Sea : a total length of 100 miles, of which only the northern 40 miles are in Israel territory.

The main tributaries of this river in Israel territory are :

(*a*) YARMUK .. To the east, total length from source to where it joins the main river—35 miles, of which only 10 miles of the lower reaches are in Israel.

(*b*) JALUD .. To the west, total length 13 miles.

Westerly Drainage

(5) QARN .. Total length from source to mouth where it flows into the Mediterranean—12 miles.

(6) NA'AMEIN .. Total length 7 miles.

(7) KISHON .. Total length 8 miles.

(8) HEFZI-BAH RIVER .. Total length from source 18 miles of which 12 miles of its lower reaches are in Israel.

(9) ALEXANDRON RIVER .. Total length 15 miles.

(10) YARKON .. Total length 15 miles.

There are no perennuel tributaries to these rivers.

The Forest

With the exception of 5,000 acres scrub forest round Qarn river in the westerly drainage, the amount of forest still standing on the upper reaches of the mountains and hills of the main rivers and their tributaries is negligable.

All the original forests have been cut and the catchment areas were under shifting cultivation and subsequent grazing".

LEBANON REPUBLIC

The area of the forests of Lebanon is about 8,000 hectares, half of which are coniferous and half broadleaved trees. This information was forwarded to me by the Directeur des Forets, Beirut, M. Antoine Salha, who said he is unable at present to afford me further information.

In the area of Lebanon the following rivers exist—14 in number, with their lengths—

	Km.		Km.
Nahr-el-Kebir	58	Nahr-el-Kalb	30
Nahr-el-Khereibe	22	Nahr-Beyrouth	24
Nahr-Arka	20	Nahr-el-Damour	31
Nahr-el-Bared	24	Nahr-el-Awali	48
Nahr-abou-Ali	42	Nahr-el-Litani	145
Nahr-el-Yaz	38	Nahr-el-Assi	46
Nahr-Ibrahim	30	Nahr-el-Hasbani	21

The Cedars of Lebanon have been known to the educated public, especially perhaps to the public trained in the Classical tradition, for a long period; also to readers of The Bible, though the references therein may require some forestry knowledge. It is known that in the thirteenth century A.D. the forests of Lebanon were described as impenetrable. For centuries the Cedars of Lebanon were and had been exported to Egypt. The timber had been used to build parts of the temple at Jerusalem, and Lebanon charcoal was well known and used and exported to Egypt and doubtless to other adjacent countries.

With a rising demand and unchecked and wasteful exploitation the Lebanon forests have disappeared and the home of the Cedars of Lebanon in the mountains is now bare.

TURKEY

Through the medium of the Turkish Embassy in London the Turkish Directorate of Woods very kindly afforded me some information and had prepared for me some useful lists of the rivers and streams, their lengths and the season at which they run or the rivers which they join.

The forests of North, West and South Anatolia cover an area of 8,379,200 hectares.

There appear to be no woods on the banks of any of the main rivers in Thrace. There are, however, thick forests in this region covering an area of 800,000 hectares along the shores of the Black Sea extending to the Bulgarian border.

In the regions of East Anatolia (Tunceli, Elaziz, Bingol) there are no woods on the banks of the main rivers ; for this season the woods situated in this region are not shown on the list. These are scattered and from large patches all over the country, covering a total surface of 810,000 hectares.

Woods of Central Anatolia are not mentioned for the same reason ; they cover a total area of 510,800 hectares.

Woods in Turkey are estimated to cover a total surface of *10,500,000* hectares at present but this should be considered as an approximate figure. More than 35% of the areas covered by woods in Turkey which formerly extended to approximately 14–15 million of hectares have been cleared to obtain passages, or destroyed by various causes. At present a great part of it is used by peasants as an agricultural area.

Turkish rivers are not at present surrounded by woods in the same lengths as in the years when statistics were carried out ; on the other hand, it should be noted that the figures given above are measurements of the parts of rivers covered by wooded areas.

Two tabular statements are attached. The first gives some information on rivers and their tributaries in Turkey which traverse forested regions under the following headings :— (1) Fleuves, Rivieres et les Principaux "bras de fleuves" qu'ils forment ; (2) Longueur en milles ; (3) La Superficie des forets traversees par ces cours d'eau ; (4) L'Endroit ou debouchent les cours d'eau ; and the number of rivers and streams mentioned is 50 as per the following table.

Fleuves, Rivieres, et les Principaux "bras de fleuves" qu'ils forment	Longueur en milles	La superficie des forets traversees par ces cours d'eau	L'Endroit ou debouchent les cours d'eau
		(hectares)	
Coruh fleuve	224	128,000	Mer Noire
Merehev riviere	216	160,000	Coruh
Oltu "	80	38,400	"
Harsit "	83	274,800	Mer Noire
Melet "	76	25,600	" "
Yesil Irmak fleuve	259	256,000	" "
Cekerek riviere	172	89,600	au Yesil Irmak
Kelkit "	221	132,400	" " "
Kizil Irmak fleuve	716	268,800	Mer Noire

Fleuves, Rivieres, et les Principaux "bras de fleuves" qu'ils forment	Longueur en milles	La superficie des forets traversees par ces cours d'eau	L'Endroit ou debouchent les cours d'eau
		(hectares)	
Devrez riviere	106	154,400	au Kizil Irmak
Goz Irmak	118	240,400	,, ,, ,,
Koca goy riviere	56	256,000	Mer Noire
Filyos ,, ...	115	253,600	,, ,,
Gerede ,, ...	118	77,600	Filyos
Arac ,, ...	61	192,000	,,
Soganli ,, ...	45	38,400	,,
Polu-Devrek riviere ..	68	203,600	,,
Melen riviere	68	380,000	Mer Noire
Sakarya flueve	491	527,600	,, ,,
Mudurmu riviere	70	115,200	Sakarya
Goynuk ,, ...	44	102,400	,,
Porsuk ,, ...	174	64,000	,,
Goksu ,, ...	68	32,000	,,
Riva riviere	56	29,200	Mer Noire
Susurluk riviere	29	64,000	au lac d'Apolyon
Kirmasti ,, ...	45	64,000	,, ,, ,,
Simav ,, ...	100	384,000	,, ,, ,,
Koca ,, ...	75	57,600	au lac de Manya
Kucuk Menderes riviere ..	62	153,600	au detroit des Mediterranean
Bakir riviere	75	64,000	a la Mer Egee
Gediz fleuve	218	96,000	au golfe d'Ismir
Gordes riviere	87	102,400	Gediz
Buyuk Menderes fleuve ..	134	192,000	a la Mer Egees
Cine riviere	48	102,400	Buyuk Menderese
Koca riviere (Dalamen riviere)	106	256,000	Akdeniz (Mediterranean)
Koca riviere	65	204,800	,,
Kopru ,, ...	97	307,200	,,
Aksu ,, ...	82	192,000	,,
Manavgat ,, ...	50	115,200	,,
Alara ,, ...	47	64,000	,,
Goksu fleuve (bras inferieur) ..	45	64,000	,,
Goksu fleuve (bras du sud) ..	85	140,800	Goksu
Goksu fleuve (bras du nord) ..	80	230,400	,,
Seyhan fleuve	321	537,600	Akdeniz
Zamanti riviere	184	57,600	Seyhan
Goksu ,, ...	117	220,000	,,
Cakit ,, ...	90	100,000	,,
Ceyhan fleuve	295	230,400	Akdeniz
Gosun riviere	81	211,200	Ceyhan
Tarsus riviere	94	128,000	Akdeniz
	50	8,379,200	YEKUN

The following rivers and streams traverse non-wooded country :—

Fleuves et Rivieres	Longueur en milles	L'Endroit ou debouchent ces cours d'eau
Firat fleuve (Euphrate)	593	Seule est consideree ici la partis du fleuve comprise dans le territoire turc
Karasu fleuve	75	Firat
Tohma riviere	122	,,
Calti ,, ...	73	,,
Kanta ,, ...	63	,,
Murat fleuve	382	,,
Hinis riviere	76	Murat
Munzur ,, ...	89	,,
Piri ,, ...	146	,,
Dicle fleuve (Tigre)	281	Seule est consideree ici la partie du fleuve comprise dans le territoire turc
Garzan riviere	65	Dicle
Batman ,, ...	83	,,
Botan ,, ...	141	,,
Zapt ,, ...	114	,,
Aras fleuve	271	Seule est consideree ici la partie du fleuve comprise dans le territoire turc
Arpas riviere	85	Aras

RESUME

8,379,000	Forets du Nord, de l'ouest et du Sud de l'Anatolie.
800,000	Foret de Thrace.
810,000	Foret de l'est de l'Anatolie.
510,000	Foret de l'Anatolie Centrale.
10,500,000	TOTAL (hectares).

IRAQ

The Director-General of Agriculture of Iraq, D. Al-Haidari, writing from Baghdad has provided me with the following interesting information on the subject of the rivers and catchment areas of Iraq. The information concerning the rivers is as follows :—

LENGTH OF RIVERS IN IRAQ

(*a*) *Chief Rivers*

1. River Euphrates from source to Qurna .. .. 1,747 miles
2. ,, Tigris ,, ,, ,, ,, ... 930 ,,
3. Shatt el Arab ,, Qurna to Fao .. .. 107 ,,

(*b*) *Chief Tributaries*

1.	KHABOUR tributary from source to TIGRIS confluence	.. 99 miles
2.	GREATER ZAB ,, ,, ,, ,, ,, ,,	.. 243 ,,
3.	LESSER ZAB ,, ,, ,, ,, ,, ,,	.. 248 ,,
4.	ADHAIM ,, ,, ,, ,, ,, ,,	.. 143 ,,
5.	DIYALA ,, ,, ,, ,, ,, ,,	.. 240 ,,

In connection with paragraphs *c*, *d*, *e*, of my questionnaire the Director-General provides the following very interesting information.

1. The Catchment area of the Euphrates lies wholly in Turkey.

2. The mountain catchments of the Tigris river and of its main tributaries fall partly within the borders of Iraq and partly in Turkey or Iran. Only the Adhaim river catchment is entirely within Iraq. The table below gives the percentage of the catchment falling within Iraq.

TABLE 1

Name of River	Proportion of catchment in Iraq	Balance of catchment to be found in
	%	
Tigris	10	Turkey
Greater Zab	54	Turkey
Lesser Zab	68	Iran
Diyala	27	Iran
Adhaim	100	..

3. We have no information regarding the state or extent of the forests in the catchments of the rivers falling outside the borders of the country. The following statistics only concern the forests of the Tigris' system within Iraq.

TABLE 2

Name of River	Approx. area of mountain catchment sq. kilometres (within Iraq)	Approx. area of forests sq. kilometres (within Iraq)	Percentage of catchment under forests
1	2	3	4
Tigris	3,230	2,710	84·5
Greater Zab ..	10,360	9,460	91·5
Lesser Zab ..	7,080	3,830	54·6
Adhaim ..	740	320	44·0
Diyala	4,140	1,330	31·8
	25,550	17,650	69·0 (average)

4. The forests areas of the Tigris system within Iraq have been divided into 4 categories as follows :—

Category	*Description*
"B" ..	Bare, high altitude land, above the oak forest zone.
"1" ..	Oak forest of good stocking density, for the most part unexploited.
"2" ..	Oak forest of good stocking density which has already been cut and exploited and should be regarded as under coppice regeneration.
"3" ..	Oak forest of low stocking density, sometimes subject to disperse shifting cultivation.

All these lands are forest land and the areas given in Table 2, column 3 comprise the totals of all four categories.

The total areas of the above categories have been computed as follows :—

TABLE 3

Category	"B"	"1"	"2"	"3"	Total
Area in sq. kilometres ..	2,574·6	6,452·7	2,882·2	5,737·5	17,647·0

Only categories "1" and "2" can be regarded as productive forest.

IRAN OR PERSIA

As an indication of how misleading figures can be Iran from the forestry point of view presents a striking example. The forest region covers some 8 per cent of the total area of the country, i.e., something over 32 million acres. This figure was furnished by the French Legation at Tehran in 1913 to Zon and Sparhawk and is given in their book *Forest Resources of the World.*

This forest area if properly distributed would make the country fully self-contained in forest produce quite apart from the possibility of considerable exports. But like other countries in the world, the Belgian Congo, e.g., this is far from being the case in Persia. As history itself tells us a considerable part of Persia is either desert or difficult mountainous country in which the scattered population exists in small areas of cultivation. It is true that the late war has opened up the country with a railway and oil pipe lines which must have a certain population to serve them which necessitates at least one or two serviceable roads. But this will not assist the poor distribution of the forest, for the latter are confined to the Caspian Provinces, the rest of the country being comparatively treeless. The extra-ordinary difficult transportation is not unnaturally responsible for the great scarcity of timber and fuel and other forest produce over the greater part of the country. In some of the desert parts it is known that former civilizations of a superior type lived, their buildings and their bones buried under a victorious sand desert, the ultimate result of man's total ignorance of and neglect of Nature's laws.

The commercial forests are situated in the northern and western parts of Iran. The Elburz Mountains in the provinces of Ghilan and Mazaderan, contain fine forests. Those in the Kurdistan and Arabia are not so good.

In the forest regions the climate is warm, the soil conditions good and the character of the forest types is varied. In the parts of Iran near the Caspian Sea there occur oak (four species) beech, several species of maple, hornbeam, alder, elm, ash, walnut, sycamore, poplar, pomegranate, boxwood and others. The forests occur principally on mountain slopes ascending to a height of from 6,000 to 7,000 feet. A characteristic feature of the Persian forests is the predominance of hardwoods and almost complete absence of conifers. In the lowlands the forests consist chiefly of alder, hornbeam, and locust ; in the mountains of oak, beech and hornbeam. In the foot-hills up to 2,000 feet hornbeam predominates over oak and beech, although oak occurs in considerable quantities together with maple, basswood, ash, and beech. Above 2,000 feet begins the zone of oak forests, in which oak forms often as much as four-fifths of the entire stand and frequently even pure stands. At altitudes of from 5,000 to 7,000 feet the predominant species is beech, and oak and other hardwoods become subordinate species.

On the Caspian shore of Iran in the Ghilan province there are oak forests of exceptional growth and quality. Before the war a Russian–Persian lumber company was interested in exploitation of the Persian forests near the cities of Resht and Enzeli. Explorations made by this lumber company over an area of nearly 400,000 acres showed that 125,000 acres were under pure stands of oak or mixed stands in which oak formed about one-third of the stand. The remaining 275,000 acres were covered with mixed hardwoods. Because of their remoteness from population and their location in the mountains, the forests had been (before the last Great War) very little exploited and a large part of the area barely touched. As a result they are composed of old trees of large dimensions and the stand per acre is considerable. Thus in the more valuable pure oak forests the number of trees per acre 3 inches in diameter breast-high and over runs as high as 111. Of this number there may be from 22 to 56 trees which are above 9 inches in diameter, and the stand per acre ranges from 5,000 to 6,000 cubic feet. The average height of the oaks is from 80 to 95 feet while the exceptional trees may even have a height of 140 feet. In the dense stand in which these forests grow the oaks are clear of branches to a height of 48 to 50 feet, have little taper, and are of great value. Besides oak, ash, beech, maple, and boxwood are also of high economic value.

Most if not all of the forests are the property of the Government.

In the distribution of its forests Iran is a good example of the conditions to which a part of a great country can be reduced by the total neglect in the past of the conditions, Nature's conditions, prevailing between the forest, cultivated lands and water supplies.

TRANSJORDAN

Situated to the east of Palestine part of the western frontier being separated from the eastern of Palestine by the Dead Sea. The altitude rises to 1,500 feet. Syria is situated to the north and Saudi Arabia to the south. An excellent map exists upon which forests still standing, on all too small an area, are shown in green, main catchment areas shown by a black line and tributary catchment areas by an interrupted black line.

Mr. W. F. Walpole, Director of Lands and Surveys gives the following information :

"I have pleasure in submitting the following in answer to your questionnaire :

(1) Schedule of existing forests.

(2) Schedule showing catchment areas of main streams. On the maps enclosed the full blue line shows where the stream is perennial and the broken line indicates the bed which only flows after heavy rain.

(3) Schedule showing length of streams.

It may interest you to learn that in the area south of the Hasa there is still some 50 square miles of juniper and *Cupressus sempervirens* forest existing on the top edge of the plateau as far as Petra which practically speaking has no connection with any catchment area : it probably extended to 300 square miles in ancient times.

This must be the forest which provided charcoal for smelting copper found in the granite mountains near Aqaba in the time of Soliman the Great.

It has only recently been taken under control by this Department and our efforts to stop destruction by promiscuous cutting and over grazing will, I hope, eventually preserve the existing forest and encourage natural regeneration".

The following is of interest :

"Areas of Forests still standing on the main rivers and tributaties. Square miles.

R. Jordan	..	23
R. Yarmuk	..	27
R. Zerka	..	57
W. el Arab	..	27
W. el Taibe	..	1
W. Ziqlab	..	50
W. el Yabes	..	42
W. Kufrinje	..	29
W. Rajeb	..	21
W. Sha'eb	..	15

"Catchment Areas of the main rivers and tributaries in square miles.

Streams flowing into the R. Jordan.

R. Yarmuk	..	544 + 2,000 in Syria
R. Zerka	..	1,247 + 128,514 in Syria
W. el Arab	..	110
W. el Taibe	..	10
W. Ziqlab	..	100
W. el Yabes	..	60
W. Kufrinje	..	49
W. Rajeb	..	42
W. Sha'eb	..	83
W. el Kefrein	..	108
W. Hesban	..	31

Rivers flowing into the Dead Sea.

W. el Mojeb	..	1,630
W. el Wala	..	713
W. Zarqa-Ma'in	..	100
W. Ibn Hemmad	..	47
W. el Kerak	..	66
W. el Hasa	..	605

"Length of main rivers and tributaries in miles.

Streams flowing into the River Jordan.

R. Yarmuk	..	69
R. Zarka	..	71
W. el Arab	..	18
W. el Taibe	..	22
W. Ziqlab	..	11
W. el Yabes	..	12
W. Kufrinje	..	11
W. Rajab	..	13
W. Sha'eb	..	23½
W. el Kufrein	..	9½
W. Hesban	..	21

Rivers flowing into the Dead Sea.

W. el Mojeb	..	79½
W. el Wala	..	36
W. Zarqa-Ma'in	..	31½
W. Ibn Hemmad	..	12½
W. el Kerak	..	19
W. el Hasa	..	62½".

CYPRUS

The following information is sent me by Mr. G. N. Sale, formerly Conservator of Forests in Cyprus.

Cyprus—3,500 square miles.

Numerous rivers of some length nearly all dry in summer outside of the forest.

1. *Pedias.*—Rising in Papoutsa Mountain 5,000 ft.
2. *Yalias.*—A deforested mountain: running through deforested and eroded waste land and cultivation.
3. *Stavros Stroumbi.*—Polis river: Stavros river comes from igneous rocks, under forest and commonly runs (gently) through the summer. The Stroumbi river comes from deforested lime-stone, partly cultivated, and runs in floods, at intervals in the winter.
4. *Morphou river.*—(These rivers have many names at various points in their course) very torrential, with wide flood bed.
5. *Small forest* rivers running all the year round for most of their course: Limniti, Kambos, Feevas, Diarrhizos, Xeros (means "dry" but it is wet in the forest) Livadhi, etc.

END

INSECT BORERS OF NEWLY FELLED TIMBER, AND THEIR CONTROL

Part 2.—The Bombay investigations of 1947–49

BY LATE N. C. CHATTERJEE AND P. N. CHATTERJEE

Branch of Forest Entomology, Forest Research Institute, Dehra Dun

FOREWORD

For some years now the Branch of Forest Entomology has been engaged in evolving suitable prophylactic methods of treatment of freshly felled timber in Indian forests, as the loss caused in the first few days or weeks of felling and before the logs are transported to the sites of conversion or utilization are very considerable. There is much demand for information regarding prophylactic methods both from forest departments and other government departments including the defence departments, as well as from private concerns. Our approach has been two-fold: first, to devise "natural or silvicultural" methods of storage in forests; secondly, by the use of insecticides. "Natural" methods, by their very nature must vary from one timber species to another, as also with the region, and we have consequently taken up three investigation with 3 or 4 common species in the Madras region, the Bombay region and the Dehra Dun (wet, North India) region. The results of the Madras investigation have already been published (Khan, 1947), those of the Bombay investigations are presented here, while those of the Dehra Dun investigations are under study.

One of the authors, the late Dr. N. C. Chatterjee, supervised the investigation in its later stages. The manuscript of the paper has been written by Dr. P. N. Chatterjee and revised by the undersigned; Dr. N. C. Chatterjee unfortunately did not live to see it.

Reference is also invited to a note by the undersigned, to be shortly published (Roonwal, 1951), in which are given practical directions on prophylactic treatments both by the "natural" methods and by the use of insecticides.

DEHRA DUN:
31st January 1951.

M. L. ROONWAL,
Forest Entomologist.

I—INTRODUCTION

Various States in India are interested in the investigations on insect borers of recently felled timbers and in their control measures. In 1945 an entomological project was taken up for the Madras Forest Department, dealing with four evergreen species, namely *Polyalthia coffeoides, Dipterocarpus indicus, Terminalia belerica* and *Vateria indica.* (Khan, 1947). In 1947 a second investigation, also dealing with 4 species, namely, *Terminalia tomentosa, Terminalia belerica, Eugenia jambolana* and *Adina cordifolia*, was taken up for the Bombay Forest Department. This investigation was concluded in early February 1949 and the results are summarized below.

One of us (P. N. C.) started the investigation in Western Forest Division, Kanara (Karwar, Bombay State) in December 1947. From February 1948, the Field Assistants Messrs. A. M. Pasford (incharge), Mohan Lal and Chandra Bahadur, continued the prescribed routine layout and observations till the duration of the project. Both of us made a final inspection of the experiments in January 1949.

The Bombay Forest Department co-operated throughout and met all the local expenses in connection with felling and layout of experiments. In particular, Mr. G. S. Singh, I.F.S., Conservator of Forests, Mr. B. F. Britto, Divisional Forest Officer, Western Division Kanara, Karwar, and Mr. Yallamali, Range Officer, Ramanguli Range, gave much help.

II—THE BOMBAY PROJECT

The field experiments were conducted from 23rd December 1947 to 1st February 1949 in the *Ramanguli Range, Western Division Kanara Forest Division, Bombay State.* The Project was designed to determine the seasonal incidence of the borers and to find out the liability of the timber to attack under different conditions of exposures such as : (i) with bark ; (ii) without bark ; (iii) kept in forest shade ; and (iv) kept in the open sun inside the forest.

Trees of each of the 4 species were felled monthly for a period of 12 months, beginning December 1947, and immediately cut into logs and billets for exposure as follows :—

(*a*) Two 6-foot logs, one with bark and the other without bark, were exposed in the forest shade ;

(*b*) Two 6-foot logs, one with bark and the other without bark, were exposed in the open sun, simultaneously with (*a*) above ;

(*c*) After cutting the above logs the remaining bole-length and branchwood (down to 12-inch in girth) from each tree were cut into 3-foot billets, divided into two equal lots and stacked criss-cross under the same conditions as (*a*) and (*b*). The logs and billets with bark intact kept under forest shade and open were given the following treatments :—

(i) One half of the log was debarked after 3 months from the date of felling and the other half after 6 months.

(ii) Of the billets with bark intact kept in open and shade, a fixed number was debarked monthly for a period of six months, leaving in the end a batch of billets with bark for comparison of incidence of attack with the debarked lots. The object of periodical debarking *was to find out the beneficial effect or otherwise of keeping the* bark intact for different periods after felling. The experiments involved the examination of 192 logs and over 1,500 billets and the identification in field and at headquarters of several thousand insect specimens.

III—INCIDENCE OF BORERS (TABLE 1–5) AND CONCLUSIONS

The principal insect borers that were found to cause economic damage to logs and billets of the 4 experimental species of trees fall under the following categories :—(1) Bostrychidæ (powder-post beetle or ghoon). (2) Cerambycidæ (sapwood and heartwood borers). (3) Scolytidæ and Platypodidæ (pinhole-borers or ambrosia beetles). (4) Curculionidæ, Anthribidæ, and Brenthidæ (sapwood borers).

The incidence of economic damage caused by the principal borer species is given below in Tables 2–5. The incidence varies with the time of felling of trees and the management of the material thereafter.

The broad lines of recommendations, based on conclusions interpreted from field observations covering about one year only, are outlined here under timber species.

(a) *Terminalia belerica*

T. belerica should be debarked within 2 months from the date of felling. *Aeolesthes holosericea* has one generation, and it can attack old fellings with bark from June to October; thus, it is important that fellings are debarked so as to eliminate the attack of *Aeolesthes.*

If the material is meant for use in a plywood factory, it requires immediate debarking outside forest in the open, and quick disposal. Otherwise, from the aesthetic point of view, the black-stained pinholes and streaks (caused by ambrosia beetles) on veneer will reduce the sale value considerably, though from the service point of view the strength is not impaired.

The extent of technical damage that may result from the powder-post beetle attack in the undressed material is within tolerance, and during dressing of log the attacked depth goes off as side-wastes. From the point of view of routine insect-hygiene these wastes should be burnt off.

(b) *Terminalia tomentosa*

The recommendations are the same as for *T. belerica.*

(c) *Adina cordifolia*

A. cordifolia should, on felling, be debarked immediately, particularly if felled in December, January and February; this measure will minimize *Xylotrechus smei* damage. The fellings of other months may safely remain with bark on, but preferably in open.

(d) *Eugenia jambolana*

E. jambolana has not been attacked by any of the serious categories of borers which cause economic damage. Fellings can remain with bark on all the year round, but preferably in the open.

IV—SUMMARY

Control measures in the forests on the following timbers in the Western Division Kanara, Bombay State are given :—

> *Terminalia belerica, Terminalia tomentosa, Eugenia jambolana* and *Adina cordifolia.* The best simple method of protection of timbers is to debark them and keep them in the open sun after removal from the forest; *E. jambolana* is, however, very resistant and may be left with bark intact.

V—REFERENCES

Khan, A. H. (1947). Insect borers of newly felled timber and their control. Part I—*Indian Forest Bulletin* (N.S.), Dehra Dun, No. 136, 8 pp.

Roonwal, M. L. (1951). Practical directions for the prophylactic treatment of timber, bamboos and plywood for protection against insect damage.—*Indian Forester,* Dehra Dun, 77(10), pp. 648–650. Also as *Indian Forest Leaflet,* No. 125, pp. 1–3. (In press).

TABLE 1.—*Insect borers found in felled timbers of Terminalia belerica, Terminalia tomentosa, Adina cordifolia and Eugenia jambolana in W.D. Kanara, Bombay State, during December 1947 to February 1949*.*

	Species of Insect borers (all Coleoptera) and species of felled timbers			
	Terminalia belerica	*Terminalia tomentosa*	*Adina cordifolia*	*Eugenia jambolana*
Fam. Bostrychidæ ..	*Sinoxylon anale* Lesne.	*S. anale*	No attack	No attack
	Sinoxylon crassum Lesne.	*S. crassum*	No attack	No attack
	Xylothrips flavipes Illiger	*Heterobostrychus æqualis* Waterh.	No attack	No attack
Fam. Cerambycidæ ..	*Aeolesthes holosericea* Fab.	*A. holosericea*	No attack	*A. holosericea*
	Xylotrechus sp.	*Xylotrechus* sp.	*Xylotrechus smei* L et G.	No attack
	Nyphasia apicalis Gahan	*N. apicalis*	No attack	No attack
	Mesosini (Lamiinæ)	Mesosini	No attack	No attack
	Coptops sp.	*Coptops* sp.	No attack	No attack
	Dihammus sp.	*Dihammus* sp.	No attack	No attack
	Monochamini (Lamiinæ)	Monochamini	Monochamini	Monochamini
Fam. Buprestidæ ..	*Sphenoptera konbirensis* Kerr.	*S. konbirensis*	No attack	No attack
	No attack	*Chrysobothris* sp.	*Chrysobothris* sp.	No attack
	Sphærotrypes sp.	*Sphærotrypes globulus* Blandf.	No attack	No attack
Fam. Scolytidæ ..	*Xyleborus butamali* Bees	*X. butamali*	*X. butamali*	*X. butamali*
	Xyleborus testaceous Wlk.	*X. testaceous*	*X. testaceous*	*X. testaceous*
	Xyleborus sexspinosus Motsch.	No attack	No attack	No attack
	Xyleborus noxious Samp.	*X. noxious*	*X. noxious*	*X. noxious*
	Xyleborus semigranosus Bldf.	*X. semigranosus*	*X. semigranosus*	*X. semigranosus*
	No attack	No attack	No attack	*Xyleborus similis* Ferr.
Fam. Platypodidæ ..	*Platypus solidus* Wlk.	*P. solidus*	*P. solidus*	*P. solidus*
	Crossotarsus minax Wlk.	*C. minax*	*C. minax*	*C. minax*
	No attack	No attack	No attack	*Crossotarsus* (nr.) *quadricaudatus* Stoch.
Fam. Curculionidæ ..	*Camptorrhinus scrobicollis* Fst.	*C. scrobicollis*	No attack	No attack
	Cryptorrhynchiniæ	Cryptorrhynchiniæ	Cryptorrhynchiniæ	Cryptorrhynchiniæ
	Rhadinomerus diversipes Mshl.	No attack	No attack	No attack
	Sipalus hypocrita Bah.	No attack	No attack	No attack
Fam. Brenthidæ ..	*Baryrhynchus miles* Bah.	No attack	No attack	No attack
	Opisthenoplus cavus Wlk.	No attack	No attack	No attack
Fam. Anthribidæ ..	No attack	*Dendrotrogus* sp.	No attack	*Androceras khasianus* ? Jord.

* Specimens with no associated adults could not be named specifically.

TABLE 2.—*Terminalia belerica*

Principal group of borers causing technical damage to felled timber with their incidences at Ramanguli Range Forest, Western Forest Division, Kanara, Bombay State—from December 1947 to January 1949.

Principal group of borers causing technical damage	Incidence
1. Serious damage in sapwood and heartwood of timber in the form of large tunnels caused by Cerambycidæ *Aeolesthes holosericea.*	Moderate to heavy attack in fellings of December, January, and March; light attack in April; no attack in May; fellings between June to November were attacked in November, the incidence being light to moderate. During summer, attack is more in shade; there is no marked difference of attack in open and shade in monsoon and autumn fellings. The monthly debarking of the felled material has shown that the maximum period that bark may remain on felled material is two months because beyond this period larvæ of *Aeolesthes* begin to enter wood. *Aeolesthes* has one generation and can attack even a six month's old fellings with bark on.
2. Damage of the "ghoon" type to starchy sapwood zone of timber caused by Bostrichidæ (powder-post beetles), e.g., *Sinoxylon anale, Sinoxylon crassum* and *Xylothrips flavipes.*	Moderate attack by *Sinoxylon anale* in December felling; negligible attack in January felling; heavy attack by *Sinoxylon crassum* in February felling; no attack between March to June felling; light attack by *Xylothrips flavipes* in July to August felling; no attack between September to November fellings. They attack starchy sapwood after it has begun to dry. Debarked timber (in preference to unbarked) is quickly attacked; the attack is more intense in open. The sapwood of timber attacked is reduced to fine wood dust; the depth of starchy sapwood zone is variable, and attack in no case was observed to exceed one inch in depth; when logs are fashioned, this depth goes off as a routine waste in saw-mills.
3. Damage in timber in the form of black stained pinholes and streaks caused by Scolytidæ and Platypididæ (Ambrosia beetles, or pinhole-borers). Species:—*Xyleborus testaceous, X. noxious, X. butamali, X. semigranosus, X. sex-spinosus; Platypus solidus,* and *Crossotarsus minax.*	Light to moderate attack by *Xyleborus* spp. and *Platypus solidus* in fellings of December to May; heavy in fellings of June and July. As soon as the bark of the timber starts decaying, the liability to attack increases; though timber is liable to attack in either condition (barked or debarked) the attack develops more in the barked condition. The incidence of attack is more in shade than in the open. The beetles do not attack dried logs. The damage caused by pinhole-borers does not impair the strength of timber seriously unless the attack is very heavy, but the black stained pinholes and streaks are objectionable in veneers.
4. Damage in the sapwood timber caused by Buprestidæ *Sphenoptera konbirensis.*	Moderate attack in December felling; light attack in January felling; no attack in February felling; light to moderate attack in May, June and July fellings; light attack in August felling; no attack in September and October fellings; light attack in November felling. The attack is confined to logs stored in the open sun in the barked condition. The larva bores into the sapwood up to one-half inch after feeding under bark for about two months. Like Bostrichidæ, during fashioning of logs, this depth goes off as a routine waste in saw-mills.

TABLE 3.—*Terminalia tomentosa*

Principal group of borers causing technical damage to felled timber with their incidences at Ramanguli Range Forest, Western Forest Division, Kanara, Bombay State from December 1947 to January 1949.

Principal group of borers causing technical damage	Incidence
1. Serious damage in sapwood and heartwood of timber in the form of large tunnels caused by Cerambycidæ *Aeolesthes holosericea*.	No attack in December felling; moderate to heavy attack in fellings of January to April; fellings between May to November were attacked in November, the incidences being light. The monthly debarking of the felled timber has shown that the larva continues feeding for about three months on the phloem tissue at the surface of wood and then tunnels into the wood as in *Terminalia belerica*. As the bark of *Terminalia tomentosa* is thicker than *Terminalia belerica* the larva of *Aeolesthes* feeds for a longer period under bark in *tomentosa* than in *belerica*. Thus the maximum period that bark can remain in felled material of *tomentosa* is three months.
2. Damage to starchy sapwood zone of timber, caused by Bostrichidæ (powder-post beetles) e.g., *Sinoxylon anale* and *Heterobostrychus æqualis*.	No attack in December felling; moderate attack by *Heterobostrychus* in January felling; heavy attack by *Sinoxylon* in February; no attack in fellings of March to September; light attack in October felling; no attack in November felling. Other details as given under *Terminalia belerica*.
3. Damage in timber in the form of black-stained pinholes and streaks caused by Scolytidæ and Platypodidæ (Ambrosia beetles or pinhole-borers), e.g., *Xyleborus tetsaceous*, *X. noxious*, *X. butamali* and *X. semigranosus*; *Crossotarsus minax*.	No attack in December to March fellings; light attack in April felling; moderate to heavy attack in May to August fellings; light attack in September and October fellings; no attack in November. Other details as given under *Terminalia belerica*.
4. Damage in the sapwood of timber caused by Buprestidæ *Sphenoptera konbirensis*.	No attack in December felling; light attack in January to April fellings; no attack in May to July fellings; light attack in August to November fellings. Other details as given under *Terminalia belerica*.

TABLE 4.—*Adina cordifolia*

Principal group of borers causing technical damage to felled timber with their incidences at Ramanguli Range Forest, Western Forest Division, Kanara, Bombay State from December 1947 to January 1949.

Principal group of borers causing technical damage	Incidence
1. Damage in sapwood of timber in the form of tunnels caused by Cerambycidæ *Xylotrechus smei.*	Light to moderate attack in December to February fellings; no attack from March to November. Monthly debarking has shown that larvæ bore through the bark and quickly enter the sapwood making tunnels right up to the centre. Fellings should be debarked immediately during the months of susceptibility.
2. Damage in timber in the form of black-stained pinholes and streaks caused by Scolytidæ, and Platypodidæ (Ambrosia beetles or pinholes), e.g., *Xyleborus butamali, X. noxious,* and *X. semigranosus; Platypus solidus; Crossotarsus minax.*	No attack in December and January fellings; light attack in February to April fellings; moderate to heavy attack in May and June fellings; light attack in July to November fellings. Other details as given under *Terminalia belerica.*

TABLE 5.—*Eugenia jambolana*

Principal group of borers causing technical damage to felled timber with their incidences at Ramanguli Range Forest, Western Forest Division, Kanara, Bombay State from December 1947 to January 1949.

Principal group of borers causing technical damage	Incidence
1. Serious damage in sapwood and heartwood of timber by way of large tunnels caused by Cerambycidæ *Aeolesthes holosericea.*	Light attack in December felling; no attack in January felling; light attack in February felling; no attack in March to November fellings. Other details as given under *Terminalia belerica.*
2. Damage in timber in the form of black-stained pinholes and streaks caused by Scolytidæ and Platypodidæ (Ambrosia beetles or pinhole-borers), e.g., *Xyleborus noxious, X. semigranosus, X. testaceous, X. butamali, Platypus solidus, P. latifinis; Crossotarsus minax.*	No attack in December to March fellings; light attack in April to July fellings; moderate to heavy attack in August felling; light attack in September to November fellings. Other details as given under *Terminalia belerica.*

THE GENUS *CAPILLIPEDIUM* STAPF IN INDIA

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SUMMARY

History of the nomenclatural complications in the genus *Capillipedium* Stapf has been reviewed. Reasons for name changes in certain species have been discussed.

Six Indian species namely *C. parviflorum* (Br.) Stapf, *C. subrepens* (Steud.) Henr., *C. hugelii* (Hack.) Camus, *C. foetidum* (Lisboa) Raizada and Jain, *C. filiculmis* (Hook. f.) Stapf and *C. pteropechys* (Clarke) Stapf have been described and illustrated.

A new name *C. fœtidum* (Lisboa) Raizada and Jain, based on *Andropogon hugelii* Hack. var. *fœtidus* Lisboa, has been proposed.

A statement of name changes in Indian species from Hooker's (1896) time onwards has been given in tabular form.

Complete bibliography is appended.

INTRODUCTION

The genus *Capillipedium* was established by Stapf (1917)169. This corresponds to the *Capillipedes* of Hackel's subgenus *Amphilophis* (1889)488. *Capillipedium* is closely allied to other members of the subgenus *Amphilophis*, which now form the bulk of the genus *Bothriochloa* Ktze.

Capillipedium has few-jointed racemes on capillary branches of the delicate panicle, and is easily distinguished from *Bothriochloa* which has many-jointed racemes, thus giving a more dense appearance to the panicle.

There are about a dozen species in the genus, distributed in tropical Africa, tropical and subtropical Asia, Australia and Polynesia, of which two species, viz., *C. subrepens* (Steud.) Henr. and *C. parviflorum* (R. Br.) Stapf, are of wide occurrence, while the rest have only restricted distribution.

Seven species are so far reported from India, of which one, *C. planipedicellatum* Bor, recently described by Bor from Assam has not been dealt with here as it has been transferred by the authors to a separate genus *Filipedium*. Two species of *Capillipedium* extend to Burma. None is so far known from Ceylon. All are economically important as good fodder for milch cattle.

The history of the nomenclatural changes in this genus dates back to 1810, when the species *Holcus parviflorus* R. Br. (1810)199 (basis of the type species *Capillipedium parviflorum* Stapf) was established. Other species belonging to this genus were originally described under *Andropogon* L. The works of Steudel (1854), Hackel (1889), and Hooker f. (1896) in the later part of 19th century stand as pioneer in the history of this genus. There have been divergent views about merging and splitting of certain species and varieties. In fact, Duthie once referred some species and varieties to the genus *Chrysopogon*.

In the first quarter of the 20th century Stapf (1917 and 1922) and Camus (1921, 1922) transferred some species from *Andropogon* to the genus *Capillipedium*. None of these authors, however, seem to have made a study of the validity of their taxonomic ranks,

Recently Henrard (1940) has thrown light on some disputed species of the genus. The nomenclatural changes suggested by Henrard may seem very drastic to those who have become accustomed to the use of certain names, and will now have to adopt new ones.

The object of this note is to clarify the position in so far as Indian species are concerned.

In the description of species we have unhesitatingly borrowed from others where an excellent one was in existence. In this respect we are particularly indebted to the works of Stapf, Blatter and Bor. The latter has always been ready to answer out repeated and often tedious questions. He has very kindly gone through the manuscript and has also given many useful suggestions.

Capillipedium Stapf (1917)169, Pilger (1940)156.

Etymology-capillus = hair, *pes* = foot, refers to the slender culms and capillary branches of panicle.

Annual or perennial grasses with slender culms, simple or branched (sometimes very copiously), frequently bearded at the nodes. Leaf-blade with a rather conspicuous white midrib. Panicles delicate, when much divided the branchlets at length more or less divergent. Spikelets small, binate, one sessile, the other pedicelled, similar in shape but differing in sex, in 1–2 (rarely up to 8) jointed racemes at the ends of the capillary primary and secondary and often tertiary or quaternary branches of a loose panicle; joints and pedicels finely filiform, longitudinally grooved and hyaline in the groove, disarticulating horizontally; sessile and pedicelled spikelets deciduous, the former with the adjacent joint and pedicel.

Florets 2 in the sessile spikelet, lower reduced to an empty glume or quite suppressed in the pedicelled spikelets, upper bisexual, 1 male or neuter, in the pedicelled spikelet. Sessile spikelet dorsally compressed, awned, callus small, shortly bearded. Glumes I and II equal, membranous to subherbaceous. Glume I 2-keeled, with narrow inflexed margins. Glume II boat-shaped, 3-nerved, keeled, grooved on both sides along the obtuse keel. Glume III hyaline, nerveless. Glume IV reduced to a hyaline, linear stipe, firmer upwards, passing into a slender awn. Palea minute or 0. Lodicules 2, minute, glabrous. Stamens 3. Stigmas exserted laterally, longer than the styles. Grain oblong-ellipsoid or oblong, dorsally slightly compressed, embryo exceeding half the length of the grain.

Stapf based his type species *Capillipedium parviflorum* (R. Br.) Stapf on *Holcus parviflorus* R. Br. Prod. (1810)199.

KEY TO THE INDIAN SPECIES

Peduncles of racemes not ciliate—

Culms more or less suffrutescent below, stiff, erect.

Glume I of sessile spikelet conspicuously chanelled. Pedicelled spikelet equal in length to sessile. Leaf-blades not much narrowed at base .. .. 1. *C. parviflorum*

Glume I of sessile spikelet flat on back, or slightly shallow near the middle. Pedicelled spikelet equal or longer than sessile spikelet. Leaf-blades much narrowed and tapering at base—

Nodes of culms usually glabrous, callus shortly bearded. Leaves usually up to 6 mm. wide, glabrous or sparsely hairy .. .. 2. *C. subrepens*.

Nodes hairy, callus densely bearded. Leaves up to 1·5 cm. wide, puberulous beneath, with scaberulous or ciliate margins .. ..

Glume IV present in pedicelled spikelet. Non-aromatic grass .. 3. *C. hugelii.*

Glume IV absent in pedicelled spikelet. Aromatic sweet smelling grass .. .. 4. *C. fœtidum.*

Culms decumbent and interlaced, very weak and filiform .. .. 5. *C. filiculme.*

Peduncles of racemes pectinately ciliate .. .. 6. *C. pteropechys.*

1. *C. parviflorum* (R. Br.) Stapf (1917)169, Haines (1924)1027, Pilger (1940)157, Bor (1940)362, Mooney (1950)187 (incl. var. *villosulus*). *Andropogon micranthus* Kunth, (1829)165, Hack. (1889)488 (incl. var. *genuinus, villosulus* and *quartinianus* Hack.); Hook. f. (1896)178 (incl. var. *villosulus* Hack.), Collett (1902)601, Prain (1903)1203, *Chrysopogon villosulus* Nees *ex* Duthie (1883)23 (excl. some syns.), *Chrysopogon montanus* Duthie (1888)40, *Holcus parviflorus* R. Br. (1810)199.

Etymology :—*parvus* = small, *florum* flowers, refers to the racemes which bear few (3 or 5) spikelets.

Description :—Perennial, innovation shoots extravaginal, their cataphylls more or less hairy, at length glabrescent. Culms tufted, to over 90 cm. high, erect or shortly ascending at the base, simple or sparingly branched, terete, internodes sometimes chanelled on the side facing the subtending leaf, glabrous. Leaf-sheaths terete, tight or at length slipping off the culms, the lowest longer, the others usually shorter than the internodes, glabrous or more or less hairy and frequently villous outside at the junction with the blade, mostly bearded at the nodes, ligules very short, truncate, ciliolate ; blades linear from an often narrowed and slightly constricted base, long tapering to a fine point, up to almost 30 cm. long, 2–5 mm. broad, rather rigid and often spreading, flat, glabrous or often pubescent all over to hirsute, particularly just above the ligule, margins rough, lateral nerves fine, 3–4 on each side.

Panicle oblong, 10–25 cm. long, 2·5–6 cm. wide, erect, more or less decompound, primary branches subverticillate, often 5–7 or more from the lowest node, unequal, and divided from lower down and up to the third degree, glabrous or hairy at their insertion, minutely puberulous all along, usually dark purple to almost black, ultimate branches (peduncles) 12–20 mm. long. Racemes reduced to 1 sessile and 2 pedicelled spikelets, or 2-rarely 3-jointed ; joints and pedicels 1·8 mm. long, shortly ciliate or sometimes glabrous. Sessile spikelet oblong, 2·8–5 mm. long, usually dark purplish or reddish to olive-brown. Glume I membranous, minutely truncate, concave along the middle on the back, about 6-nerved (2 intracarinal), scabrid all over, ciliate upwards on the keels ; glume II similar, scaberulous upwards on the keel ; glume III 2–2·5 mm. long ; awn including stipe (glume IV) 1·25–2 cm. long, fine. Anthers 1·6–1·8 mm. long. Pedicelled spikelet usually male, very similar to the sessile or little smaller, narrower and paler. Glume I acute, 7-nerved ; keels ciliolate upwards. Upper floret suppressed.

Distribution :—Widely distributed throughout India, Burma, Malaya, Australia, South Africa.

Ecology :—Found usually in drier parts, ascending up to 6,000 feet.

Hooker (1896)178, following Hackel (1889)490, described a variety *villosulus* Hack. Stapf (1917)170 does not recognize this variety as distinct. An examination of the material at our disposal leads us to the same conclusion as that of Stapf. There is a range of variation from hispidly hairy nodes, leaf-sheaths and blades to almost glabrous.

2. *C. subrepens* (Steud.) Henrard (1940)463 ; *Andropogon subrepens* Steud. (1854)397, *A. assimilis* Steud. (1854)397, *A. montanus* Hack. (1889)490 (not of Roxb.) under *A. assimilis* in Hook. f. (1896)179, Lisboa (1896)72, Cooke (1908)981. Under *Capillipedium*

assimile Camus (1922)314, Blatter and McCann (1935)80, Bor (1940)363, *C. assimilis* Haines (1924)1028 *partim*, under *C. glaucopsis* (Steud.) Stapf (1922)3085, Fischer (1934) 1730, Pilger (1940)157, Rhind (1945)67.

Etymology :—*subrepens* = shortly creeping, probably refers to the decumbent base of culms.

Description :—Perennial. Culms 1·8–3·5 m. tall, suffrutescent, decumbent and rooting at the base, branching, internodes very glabrous, round but flattened on one side, nodes glabrous branches spreading. Leaf-blades flat, almost lanceolate, linear, base very narrow, insensibly acuminate-setaceous, 6–15 cm. long, 3–6 mm. broad, flat, spreading, soft, glabrous or hispidulous, often scaberulous, with the margins spinous toothed, median nerve somewhat thick, broad and white above, sheaths somewhat compressed, subcarinate, the lower slipping from the culm, all shortly bearded in the throat, nodes somewhat hairy, smooth or scaberulous ; ligules short, truncate, ciliolate or hairy.

Inflorescence a decompound panicle, 5–12 cm. long, slender, erect, ovate-oblong or triangular, branched to the third degree ; common axis slender ; branches and branchlets capillary, spreading at a right angle after anthesis, bearded in the axils, naked at the base, the primary solitary, rarely opposed, the secondary numerous ; racemes 7–10 mm. long, peduncled, 2–3-jointed, rhachis smooth, fragile ; joints and pedicels 1·5–2·5 mm. long, filiform, back deeply chanelled, hyaline ; margins ciliate or glabrescent ; hairs ·75–1·25 mm. long, often absent at the top ; articulations without appendages. Sessile spikelets linear-oblong, 2–3·5 mm. long, all hermaphrodite, dorsally compressed, pale green or reddish, aristate. Glume I membranous, oblong or linear-oblong margins narrowly-inflexed, 2-keeled, very narrowly truncate at the top, somewhat depressed on the back, towards the top glabrescent, with stiff cilia on the keels, delicately 2–5-nerved ; callus small, shortly bearded ; glume II 2–3·5 mm. long, broadly lanceolate and ciliolate at the apex, acute or mucronate, sub-depressed towards the obtuse keel, margins glabrous, 3-nerved. Lower floret barren ; glume III ·75–1·25 mm. long, hyaline, ovate, obtuse, nerveless, glabrous. Upper floret bisexual ; glume IV ·75–1·2 mm. long, narrow, glabrous ; awn very slender 6–12 mm. long ; palea 0. Lodicules glabrous. Stigmas oblong, broadly plumose, almost twice as long as the styles. Pedicelled spikelets male or neuter, 3·5 mm. long, linear-lanceolate, rusty. Glume I linear lanceolate, acute, green or reddish, keel ciliolate, remainder glabrous, 7-nerved ; glume II 3·5 mm. acute, 3–5-nerved, ciliolate ; glume III shorter, oblong, obtuse, nerveless, glabrous, empty. Upper floret male, anthers 1·2 mm. long, stamens scarcely absent ; glume IV 0.

Distribution :—N.W. India, Rajasthan, Bihar, Bengal, Madhya Bharat, West Peninsula, Burma, Java, China, Japan.

Ecology :—Usually growing among other grasses being supported by them. Common in dry open places and in deciduous forests.

C. subrepens Henr. var. *glaucophyllum* Henr. (1940)463 ; *Andropogon glaucopsis* Steud. (1854)397 (not of Steud. 1840). *Chrysopogon glaucopsis* Duthie (1883)22.

Nodes of the culms and branches bearded.

Distribution :—Temperate Himalayas, Khasia ; Burma.

There had been considerable confusion about the nomenclature of this grass [*C. subrepens* (Steud.) Henr.]. Roxburgh (1832) I, 267 described a grass *Andropogon montanus* Roxb. from northern Circars ; Bentham (1861)423 quoted another grass from Honkong and mistaking it to be the same as Roxburgh's described it as *A. montanus* Roxb. Hackel, following Bentham, described in his monograph (1889)490, *A. montanus* Roxb. and distinguished there

in two varieties 'a' and 'b'. He referred var. 'a' to *A. assimilis* Steud., and var. 'b' to *A. glaucopsis* and *subrepens* Steud. Hooker (1896)177 pointed out this error of Hackel, and in the end of the description of true *A. montanus* Roxb. he mentions :—

> "......I have seen no plant resembling this species, which is a native of a region botanically unexplored since Roxburgh's day. It has obviously no affinity with that which Hackel, following Bentham, has described as *A. montanus* Roxb. and which plant Roxburgh probably never saw".

The true *A. montanus* Roxb. does not belong to the genus *Capillipedium* but is probably a *Bothriochloa.*

Steudel (1854)397 described three species *Andropogon glaucopsis* Steud. *A. subrepens* Steud., and *A. assimilis* Steud. These three as well as *A. montanus* Hack. (not Roxb.) are very closely allied, and are rather one and the same species with some inconsistent variations.

A. subrepens Steud., *A. assimilis* Steud. and *A. montanus* Hack. have glabrous nodes of culms, while *A. glaucopsis* Steud. has bearded nodes.

In 1922 (p. 314) Camus transferred *A. assimilis* to *Capillipedium* as *C. assimile* (Steud.) Camus, and kept *A. glaucopsis* and *subrepens* Steud., as synonyms. A little later in the same year Stapf, made the combination *C. glaucopsis* Stapf based on *A. glaucopsis* Steud. and kept *A. subrepens* and *assimilis* Steud. in synonyms.

Henrard (1940)462 points out that *A. glaucopsis* can not be separated as a distinct species merely on the basis of the single character of hairiness of nodes. He regards this taxon to be of a varietal rank only. Henrard reduced the three species *A. subrepens* Steud. *A. assimilis* Steud. and *A. montanus* Hack. to one species which he named *Capillipedium subrepens* (Steud.) Henr. and considered *A. glaucopsis* Steud. with hairy nodes to be a variety of *C. subrepens.* But the specific epithet *glaucopsis* having been preoccupied in the genus *Andropogon* by Steud. himself in 1840 for another grass is abandoned, and a new name *glaucophyllum* Henr. has been proposed for this variety with hairy nodes. Thus *C. subrepens* (Steud.) Henr. var. *glaucophyllum* Henr. is the name for *A. glaucopsis* Steud. (1854 not 1840).

Among the Indian floras we find that both the names *C. assimile* Camus, and *C. glaucopsis* Stapf, have been used by various authors relating to the same grass, which shall now be called *C. subrepens* (Steud.) Henr. or its var. *glaucophyllum* Henr. as the case may be.

3. *C. hugelii* (Hack.) Camus in Rev. de Bot. appl. et d' Agricult. No. 4 (1921)306 ; Henrard (1940)458. *C. hugelii* (Hack.) Stapf (1922))3085, Fischer (1934)1730 ; *C. hugelii* Blatter and McCann (1928)420, (1935)81 *Andropogon hugelii* Hack. (1889)492, Duthie (1888)88, Hook. f. (1896)180, Cooke (1908)982, *A. schmidii* Hook. f. (1896)180.

Etymology :—After Baron C. Huegel, a botanical traveller in India in the 19th century.

Description :—Perennial. Culms often suffrutescent below, frequently red, branching from the base, the branches 75–105 cm. long, nodes bearded. Leaf-blades 10–20 by 2–1 ·3 cm., linear-lanceolate, acuminate, flat, flaccid, green, narrowed at the base, the margins scaberulous or sometimes ciliate ; sheaths bearded at the mouth, otherwise glabrous ; ligule membranous, ciliate.

Panicle 5–9 cm. long, branches capillary with bearded axils ; joints and pedicels ciliate. Sessile spikelets 3 mm. long, pale green or purplish ; callus densely villous ; glume I chartaceous, ovate, truncate, villous below the middle or glabrous, margins narrowly incurved, the keels ciliate with long hairs ; glume II equal to I, glabrous, narrowly truncate, shortly apiculate, glume III 1 ·5 mm. long, hyaline, ovate, obtuse glabrous ; glume IV represented by the slender, white, not dilated base of the awn ; awn up to 2 ·5 cm. long. Pedicelled spikelets 4 mm. long, lanceolate, green or purple ; glume I subacute, 9 to 11-nerved, pubescent up the back and with

ciliate keels ; glume II equal, acuminate, the keels minutely ciliate ; glume III oblong, obtuse, hyaline, nearly equal to glume II, nerveless ; glume IV narrowly linear.

Distribution :—Rajasthan, Madhya Pradesh, Madhya Bharat, West Peninsula.

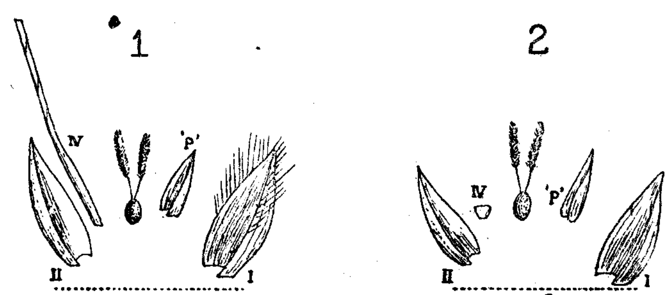
Lisboa (1896)73 mentions a variety *fœtidus* Hack. based on the species *Andropogon fœtidus* Hack. *mss.* He separates it from *A. hugelii* on the basis of absence of glume IV in the pedicelled spikelets and the sweet smell of the grass, and he also mentions absence of glume III in the sessile spikelets of all the specimens examined by him. For this variety Hooker (1896)180 states—

> "......I fail to find any characters in the specimens I have examined, or in the descriptions given, to distinguish it from *A. hugelii*, except that according to Lisboa the pedicelled spikelet of *fœtidus* has no glume IV".

There are about a dozen sheets in the Dehra Dun herbarium named *A. fœtidus* Hack. or *A. hugelii* Hack. var. *fœtidus* Hack. All these sheets bear the remark :—"Sweet scented". An examination of these specimens revealed that invariably all of them have no glume IV in pedicelled spikelet.

As regards the presence or absence of glume III in the sessile spikelet, the following observations are noteworthy :—

> There is a hyaline structure about 1·5 mm. long and 1 mm. wide, embracing the ovary, and situated adjacent to the glume I. According to its position this can be either glume III or palea of the upper bisexual floret. A similar structure more or less identical in shape, size and position in *Capillipedium planipedicellatum* Bor has been regarded by Bor as palea of upper floret. We feel that since this hyaline structure embraces the ovary of the upper floret, it is better regarded as the latter's palea.



1. *C. foetidum* Raizada & Jain. 2. *C. planipedicellatum* Bor. (Sessile spikelet dissected, stamens not shown ; 'p'–Palea).

We are inclined to believe that the constant absence of glume IV in the pedicelled spikelet, coupled with the characteristic odour of this grass justify raising it to a specific rank, and we propose the name *Capillipedium fœtidum* (Lisboa) Raizada and Jain *status. nov.* (= *Andropogon fœtidus* Hack. *nomen ; A. hugelii* Hack. var. *fœtidus* Lisboa (1896)73.

4. *Capillipedium fœtidum* (Lisboa) Raizada and Jain ; *Andropogon hugelii* Hack. var. *fœtidus* Lisboa-Bomb. Grass. (1896)73 ; *Andropogon fœtidus* Hack. *nomen.*

A perennial sweet scented grass. Culms slender, decumbent and rooting at the base, then ascending to 75–120 cm. high or more ; grooved on the side of leaves and branches, glabrous, pale purple ; nodes bearded with white hairs. Leaf-blades 12–20 by 1·2 cm. linear-lanceolate, acute, with a few hairs on the lower surface, fewer or none on the upper, distinctly divided into two unequal parts by a white rib, which is prominent on the lower surface.

Panicle 10–15 cm. long, oblong, much branched, on a long peduncle. Rhachis of a pale purple colour, smooth or scabrous from minute tubercles, 6 to 9-jointed. Branches many at each joint (6–12 at the lower joints), capillary, smooth or scabrous, unequal in length ; articulations of the main rhachis and primary branches swollen and bearded with long, soft, white hairs ; secondary branches 2–4 at each joint of primary branches. Small tertiary branches too often present ; the ultimate branches bearing a terminal triad of spikelets, one sessile between 2 pedicelled ones, and generally 3 pairs below the triplet. Joints and pedicels shortly hairy. Spikelets yellowish white or dingy green ; callus hairy. Sessile spikelet. Glume I ovate, truncate, glabrous or sparsely hairy, 7 to 9-nerved ; glume II broader, glabrous, 5-nerved ; glume III absent ; glume IV represented by a slender twisted awn bisexual, its palea hyaline 1·5 mm. long 1 mm. wide. Pedicelled spikelet. Glume I ciliolate at the margins, many-nerved ; glume II 3-nerved ; glume III broader than II, hyaline ; glume IV absent. Stamens 3, 2 mm. long.

Khandwa, Chanda, Chandra (Duthie) ; Bassein, Thana, and Ghats in Bombay.

This sweet scented grass has been collected from damp situations in Madhya Pradesh and Bombay.

5. *Capillipedium filiculme* (Hook. f.) Stapf (1922)3085, (1934)1730, *C. filiculme* Blatter and McCann (1928)420, (1935)81, *Andropogon filiculmis* Hook. f. (1896)181, Cooke (1908)982.

Etymology :—*filum* = thread, *culmis* = stem, refers to its thin and slender culms.

Description :—Annual. Culm 60–90 cm. long, decumbent and interlaced, copiously geniculately branched, weak, filiform, quite glabrous ; internodes long ; nodes bearded, leaf-blades 5–10 cm. by 3–4 mm., linear-lanceolate finely acuminate with filiform tip, glabrous above, glabrous or sparsely hairy beneath, flaccid, suddenly narrowed at the base, pale green, the midrib and nerves slender ; sheaths bearded at the very tip, otherwise glabrous, the lower sheaths open below ; ligule membranous, ciliate.

Panicles 2·5–5 cm. long, branches few, filiform. Spikelets 2 or 3, pale green or white, pedicels of upper spikelets ciliate with long hairs. Sessile spikelets 3 mm. long oblong-lanceolate, callus densely villous ; glume I oblong-lanceolate, obtuse, membranous, 5 to 7-nerved, villous below the middle or all over, the keels ciliate ; glume II thinly membranous, lanceolate, acute, shortly mucronate, 3-nerved, glabrous ; glume III small, ovate, obtuse, nerveless, hyaline ; glume IV represented by an awn 13–16 mm. long, the lower half dark brown, the upper half yellowish white, the base not dilated, white for about 2 mm. Pedicelled spikelets equal to sessile but narrower ; glume I ovate-lanceolate, acute, 7 to 9-nerved, ciliate ; glume II lanceolate, strongly 5-nerved ; glume III broadly oblong, obtuse, hyaline, nerveless, equal to I and II ; glume IV absent.

Distribution :—Western Peninsula, Mysore.

Ecology :—A weak grass with stilt roots from the nodes.

6. *C. pteropechys* (Clarke) Stapf (1922)3085, Bor (1940)364, *Andropogon pteropechys* Clarke (1889)88.

Etymology :—*pterux* = wing, *pechys* = foriarum, refers probably to the ciliate stalk of racemes.

Description :—Perennial. Culms very slender from a creeping root stock, stout, 40–60 cm. high, terete, glabrous and smooth, finely striate, nodes bearded sparingly branched or

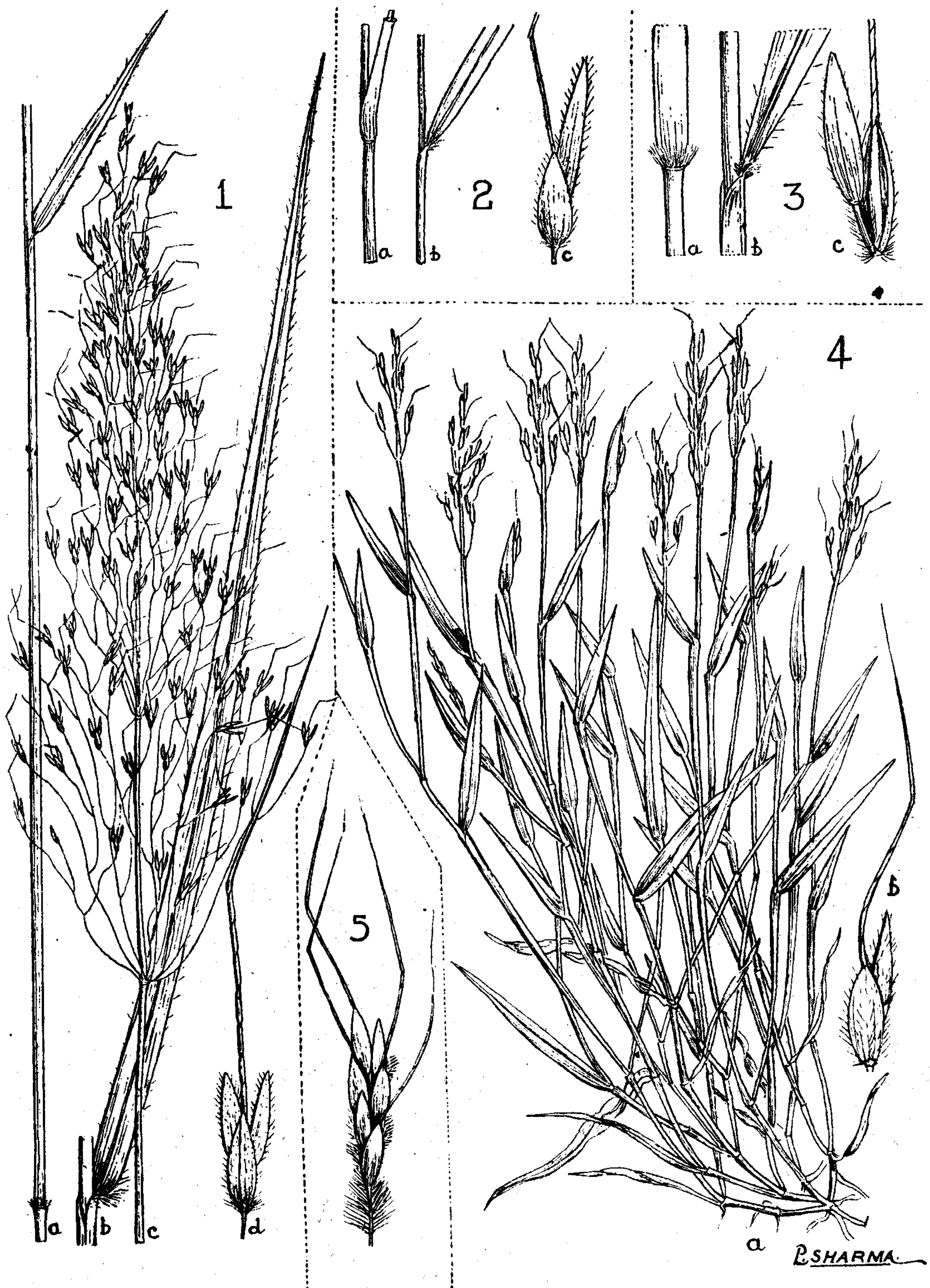
simple. Leaf-blades 7·5–15 cm. long, linear-lanceolate, finely acuminate, narrowed towards the base, glabrous above, below sparsely hairy from tubercled bases, scaberulous on the upper surface, margins scarcely thickened, scabrid, midrib distinct above as a white line ; sheaths rather loose below, close and tightly fitting above, striate, smooth and glabrous, except for a few hairs at the collar and a few at the mouth, ligule a very narrow, ciliate rim ; cilia stiff.

Inflorescence a very open panicle 5–7·5 cm. long, sparingly branched ; branches filiform, smooth and glabrous except just below the spikelet where they are pectinately ciliate ; hairs white. Racemes usually few spiculate, about 1 cm. long, joints and pedicels ciliate on the margins, chanelled, usually about half the length of the spikelets. Spikelets oblong, somewhat obtuse, erect ; callus hairs equalling $\frac{1}{4}$ the length of the spikelet. Sessile spikelets 3·75–4·25 mm. long ; glume I oblong-obtuse, more or less rounded on the back, quite glabrous, keels pectinately ciliate, 9-nerved, nerves usually prominent ; glume II ovate-lanceolate, acute, 3-nerved, sparingly ciliate. Lower floret barren ; glume III small, ovate, nerveless ; palea 0. Upper floret hermaphrodite ; glume IV the linear base of an awn 1·5 cm. or more long ; palea very small or absent. Pedicelled spikelets male or barren, rather narrower than the sessile and more acute ; glume I 9 to 11-nerved ; glume II thin membranous, 3-nerved, glume III oblong-obtuse, glabrous and nerveless ; anthers 2 mm. long.

Distribution :—Naga hills, Assam.

Statement of name changes in Indian species of Capillipedium.

Name in Hooker's Fl. Br. Ind.	Name used in the later Indian floras.	Correct name.
Andropogon micranthus Kunth. *A. micranthus* Kunth. var. *villosulum* Hack.	*Capillipedium parviflorum* (R. Br.) Stapf.	*C. parviflorum* (R. Br.) Stapf.
A. assimilis Steud.	*C. assimile* (Steud.) Camus. *C. glaucopsis* (Steud.) Stapf.	*C. subrepens* (Steud.) Henr. and *C. subrepens* Henr. var. *glaucophyllum* Henr.
A. hugelii Hack. *A. schmidii* Hook. f.	*C. hugelii* (Hack.) Stapf.	*C. hugelii* (Hack.) Camus.
A. hugelii Hack. var. *fœtidus* Lisboa (not given in Fl. Br. Ind.)	..	*C. fœtidum* (Lisboa) Raizada and Jain.
A. filiculmis Hook. f.	*C. filiculme* (Hook. f.) Stapf.	*C. filiculme* (Hook. f.) Stapf.
A. pteropechys Clarke.	*C. pteropechys* (Clarke) Stapf.	*C. pteropechys* (Clarke) Stapf.
	C. planipedicellatum Bor.	Transferred to the genus *Filipedium* Raizada and Jain.



1. *Capillipedium parviflorum* Stapf. 2. *C. subrepens* Henr. 3. *C. hugelii* Camus. 4. *C. filiculme* Stapf. 5. *C. pteropechys* Stapf.

EXPLANATION OF PLATE.

1. *Capillipedium parviflorum* (Br.) Stapf.
   (*a*) A portion of culm × 1.
   (*b*) Leaf × 1.
   (*c*) Inflorescence × 1.
   (*d*) A raceme × 5.
2. *C. subrepens* (Steud.) Henr.
   (*a*) Node of culm × 1.
   (*b*) Leaf base × 1.
   (*c*) A pair of spikelets × 5.
3. *C. hugelii* (Hack.) Camus.
   (*a*) Node of culm × 1.
   (*b*) Leaf base × 1.
   (*c*) A pair of spikelets × 5.
4. *C. filiculme* (Hook. f.) Stapf.
   (*a*) Habit × ½.
   (*b*) A pair of spikelets × 5.
5. *C. pteropechys* (Cl.) Stapf.
   A raceme with ciliate peduncle × 3.

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A NOTE ON THE EXTRACTION OF CHLOROPHYLL PIGMENT FOR COLOURATION OF HYDROGENATED FATS

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A simple, economic method of colouration of Vanaspati with chlorophyll pigment by direct extraction of the leafy materials with the fat itself has been developed. The new method avoids the use of any costly solvents.

Chlorophyll has been suggested[1, 2] for colouration of Vanaspati, as (1) it is easily extractable from readily available indigenous plant sources, (2) it is not only non-toxic, but is also known to be highly beneficial to health[3, 4] when taken in orally, (3) it imparts a pleasing yellowish green colour to the fat and (4) it can be readily detected both by visual as well as chemical tests so that the chlorophyllized fat cannot be used for adulterating pure *ghee*. In the original experiments, the pigment as extracted by the method of Willstätter and Stoll[5] was used to colour Vanaspati and such samples of "chlorophyllized Vanaspati" have been found to retain the fresh natural yellowish green colour even after storing in glass containers for a period of one year. It has now been found that this colour can be imparted to the fat by a direct extraction of the leafy material with the fat itself. This modification saves much labour, equipment and the use of costly solvents and thereby effects a considerable economy in the production costs.

The following table illustratres the intensities of colour produced when varying amounts of the leafy powder of *Urtica parviflora* Roxb. (stinging nettle) are heated with ' Dalda ' for different periods at different temperatures.

TABLE

% leaf powder	Duration of extraction	Temperature of extraction	Intensity of colour in ½ cm. cell in Lovibond tintometer		
			Yellow	Blue	Red
2·0	1 hour	40°C	28	0·5	0·2
2·0	1 ,,	60°C	32	1·8	0·3
2·0	1 ,,	80°C	50	1·4	0·3
2·0	1 ,,	100°C	25	0·2	1·5
10·0	1 ,,	60°C	65	10	3·0
10·0	10 hours	40°C	90	10	1·5
10·0	40 ,,	Lab. Temp. (Cocogem used)	105	5	1·5

From the above results it is clear that the greatest intensity of colour is obtained by carrying out the extraction at 40°C for 10 hours. Further, when extracted under these conditions, the colour is quite bright and stable, while extraction at higher temperatures

tends to impart a dull shade which has a tendency to become dirty green and fade away within a short time. Since the product gives as high a blue value as 10 units, it can be diluted with fresh quantities of colourless Vanaspati by at least five times, thus giving a chlorophyllized fat corresponding to about 2 blue units, which in our opinion is about the minimum concentration of colour suitable for Vanaspati.

The method of extraction of the pigment with Vanaspati is as follows :—Air dry green leaf powder, about 10 per cent by weight of Vanaspati, is thoroughly mixed with the fat by means of a mechanical stirrer for 10 hours maintaining the temperature of the mixture at 40°C. At the end of the experiment, the melted Vanaspati is filtered and the intensity of the colour is measured in a $\frac{1}{2}$ cm. cell in a Lovibond tintometer. The dark yellowish green Vanaspati is then diluted with further quantities of colourless Vanaspati to get "Chlorophyllized Vanaspati" corresponding to two Lovibond blue units when examined in a $\frac{1}{2}$ cm. cell.

From the above results it can be easily seen that for the annual production of 200,000 tons of Vanaspati in this country 4,000 tons of dry edible leaf powder such as from stinging nettle (*Urtica parviflora* Roxb.) or *palak* (*Spinaceæ oleracea* Linn.) will be required. Any other common leafy vegetable like *sarson* and its allies (*Brassica* sp.), could also be used for the purpose with equal facility. The process is very simple and easily amenable to industrial operations.

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PROTEINS OF THE SEEDS OF SOME INDIAN FOREST TREES

Cassia tora, Terminalia belerica and Duabanga sonneratioides

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SUMMARY

The chief protein of the seeds of *Terminalia belerica* and *Duabanga sonneratioides* is globular in nature. The seeds of *Cassia tora* are rich in both albumins and globulins.

The proteins have been analysed for their Van Slyke nitrogen distribution and tyrosine and tryptophane contents.

The *Terminalia belerica* and *Cassia tora* globulins while comparing favourably with the globulins of *Santalam album,* are rather poor in tryptophane content as compared with *Dolichosin* but are superior to *Cajanin.* The *Duabanga sonneratioides* globulin is poor in cystine also.

The albumins from *Terminalia belerica* and *Cassia tora* are essentially inferior to the albumin from *Cajanus indicus* in their cystine contents.

In connection with various investigations in progress in this laboratory it was thought of interest to investigate the proteins of the seeds of some forest trees, data on which is not available. The present investigation deals with the proteins of the seeds of *Cassia tora, Terminalia belerica* and *Duabanga sonneratioides.*

Cassia tora is a gregarious annual shrub (1–2 ft. in height) abundant throughout the tropical parts of India, especially U.P. and Bengal. The seeds are eaten in times of food scarcity and in Burma and the Arakan a kind of coffee is made from the seeds and leaves. The seeds are also said to be used as a remedy for ringworm and itch. *Terminalia belerica* is a large deciduous tree common in the plains and lower hills throughout India. The fruit is exported under the name of myrobolan along with the seeds of *Terminalia chebula* and is employed for dyeing and tanning. The seeds yield a fatty oil to the extent of 38%. The seeds are described as astringent and laxative and useful in cough, etc., *Duabanga sonneratioides* is a lofty tree. The seeds are small.

EXPERIMENTAL

Cassia tora seeds were knidly supplied by the Forest Botanist. *Terminalia belerica* seeds were obtained in Dehra Dun and *Duabanga sonneratioides* seeds were kindly supplied by the Assam Forest Department.

Proximate analysis of the seeds.—Defatted and finely powdered seeds of *Terminalia belerica* were used. The seeds of *Cassia tora* and *Duabanga sonneratioides* were cleaned, dried and powdered. Proximate analysis of the tree seeds carried out according to the methods of A.O.A.C. gave the following results :

TABLE I.—*Proximate analysis of the seeds*

Species	Moisture %	Ash %	Ether extractives %	Nitrogen %	Protein %	Fibre and carbohydrates (by difference) %
Terminalia belerica (defatted)	10·61	3·33	0·33	5·70	35·52	50·13
Cassia tora	6·70	6·38	12·15	2·77	17·36	57·41
Duabanga sonneratioides ..	7·92	2·34	4·20	2·11	13·18	76·09

Distribution of nitrogen in the seed meal.—The nitrogen distribution in the meal was ascertained by extracting it successively with different solvents and the percentages of nitrogen extracted were as given in Table II.

TABLE II.—*Distribution of nitrogen in the seed meals*

Solvent	% Nitrogen extracted		
	Terminalia belerica	*Cassia tora*	*Duabanga sonneratioides*
Water	12·20	48·93	9·30
4% Sodium chloride	72·87	35·62	60·62
70% Ethyl alcohol	2·40	0·98	1·10
0·4% Sodium hydroxide ..	10·72	12·62	12·69
TOTAL ..	98·19	98·15	83·71

Almost all the nitrogen is accounted for in the case of *Terminalia belerica* and *Cassia tora* but not in the case of *Duabanga sonneratioides*. All the three seeds are rich in globulins. *Cassia tora* has a high content of albumins also. After preliminary experiments the albumins and globulins were prepared as follows :

Preparation of the albumins.—500 gms. of the meal were extracted with distilled water in glass stoppered bottles, the extract centrifuged and the clear extract dialysed for 15 days. The globulin precipitate was separated from the supernatant albumin solution by centrifuging. The clear albumin extract was now acidified with acetic acid and heated for a few minutes at 61°C in the case of *Terminalia belerica* protein and at 54°C for *Cassia tora* protein. The coagula obtained were carefully washed with ethyl alcohol of graded strength and finally with pure dry ether and dried in a vacuum desiccator over concentrated sulphuric acid. The albumins on analysis gave the following figures.

TABLE III.—*Proximate analysis of albumin*

Species	Moisture %	Ash %	Ether extractives %	Nitrogen %	Sulphur %
Terminalia belerica albumin ..	3·90	0·69	0·23	14·83	1·23
Cassia tora albumin	4·22	0·49	0·19	14·12	1·61

Preparation of the globulins.—The seed meal was extracted in batches of 500 gms. at a time. The meal was suspended in 2 to 2·5 litres of 0·4% sodium chloride solution, a few cc. of toluene being added. This was stirred for 2 to 3 hours filtered through fine cloth and the extract centrifuged. The extract was centrifuged a second time and the clear extract dialysed in cellophane bags for 15 days, toluene being used for keeping it aseptic. The precipitated globulin was freed from the albumin and washed repeatedly with distilled water and dilute ethyl alcohol. It was then washed with ethyl alcohol of graded strength and finally

with pure dry ether and dried over concentrated sulphuric acid under vacuum, The *Terminalia belerica* globulin was yellowish white in colour, that of *Cassia tora* brownish and that of *Duabanga sonneratioides* greenish white.

Proximate analysis of the globulins gave the following results.

TABLE IV.—*Proximate analysis of globulins*

Species	Moisture %	Ash %	Ether extractives %	Nitrogen %	Sulphur %
Terminalia belerica globulin ..	6·97	1·1	0·69	15·10	0·71
Cassia tora globulin	5·12	1·4	0·43	15·40	1·41
Duabanga sonneratioides globulin ..	4·93	1·0	0·39	14·00	0·69

Nitrogen distribution in the proteins.—2·5 or 3·5 gms. of the protein (according to availability) were boiled with hydrochloric acid (specific gravity 1·115) till the reaction mixture no longer gave the biuret reaction. The hydrolysate was analysed according to van Slyke, advantage being taken of all the improvements suggested by Plimmer and Rosedale (1925), Daft (1924), Linderstrom-Lang (1927–9) and others. The results are given in Table V.

TABLE V.—*Van Slyke distribution of nitrogen in albumins*

Form of Nitrogen	ALBUMIN FROM		
	Terminalia belerica	*Cassia tora*	*Cajanus indicus*
Amide	9·12	9·92	9·05
Humin (insoluble)	1·25	1·47	1·62
Humin (soluble)	1·25	1·26	1·52
BASIC			
Arginine	9·55	11·33	12·04
Histidine	7·64	3·40	1·31
Cystine	1·14	1·40	4·43
Lysine	4·78	5·64	7·18
NON-BASIC			
Amino	60·5	60·41	59·26
Non amino	4·18	3·80	3·58
TOTAL ..	99·41	98·63	99·99

Values for essential amino acids are given below : Table VI. Tyrosine and tryptophane were determined by the method of Folin and Looney.

TABLE VI.—*Percentages of essential amino acids in the albumins*

Amino acid	ALBUMIN FROM	
	Terminalia belerica	*Cassia tora*
Arginine	4·75	5·64
Histidine	4·51	2·01
Lysine	3·99	4·71
Cystine	1·56	1·92
Tyrosine	1·42	2·13
Tryptophane	0·23	0·69

From the results given above it is clear that these albumins are characterized by a lower content in arginine as compared with globulins. The results of analysis of the globulins are given in Tables VII and VIII.

TABLE VII.—*Van Slyke distribution of nitrogen in globulins*

Form of Nitrogen	GLOBULIN FROM					
	Terminalia beleria	*Cassia tora*	*Duabanga sonneratioides*	*Santalum album*	*Dolichos lab lab*	*Lathyrus sativus*
Amide	11·05	12·43	8·80	8·08	10·49	10·21
Humin (insoluble)...	1·11	1·28	2·04	1·11	1·33	1·25
Humin (soluble) ..	0·89	1·21	0·41	1·08		0·71
BASIC						
Arginine ..	22·02	15·05	19·72	21·04	16·84	3·93
Histidine ..	3·87	3·46	4·46	1·85	1·50	1·45
Lysine ..	5·30	10·15	2·95	7·90	8·20	12·83
Cystine ..	1·01	1·28	0·62	0·57	0·79	0·53
NON-BASIC						
Amino ..	54·39	53·22	56·45	56·71	56·35	61·51
Non amino ..	2·29	4·17	5·26	2·35	3·77	7·23
TOTAL ..	101·93	102·25	100·71	101·00	99·27	99·65

Both the globulins in common with other globulins are characterized by a high percentage of basic nitrogen. The essential amino acid make up is given in Table VIII.

TABLE VIII.—*Percentages of essential amino acids of globulins*

Amino acid	Globulins from					
	Terminalia belerica	*Cassia tora*	*Duabanga sonneratioides*	*Santalum album*	*Dolichos lab lab*	*Cajanus indicus*
Arginine ..	10·95	7·49	9·81	10·63	8·11	5·72
Histidine ..	2·29	2·04	2·63	1·09	0·86	2·99
Lysine	4·43	8·48	2·46	6·60	6·63	6·93
Cystine	1·39	1·76	0·85	2·04	0·96 to 1·02	1·39 to 1·41
Tyrosine ..	2·67	2·93	2·20	5·99	4·86 to 5·68	3·16
Tryptophane ..	0·56	0·74	0·39	Present	2·46 to 2·59	0·12

As will be seen from Table VIII *Cassia tora* globulin compares favourably with the other globulins in its essential amino acid contents.

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SATURDAY NIGHT

BY J. N. SINHA, B.SC.

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News arrived that large scale theft of *Sabai* grass had started in the reserved forests, such as had neither been imagined nor witnessed before. It was not of the known grab-and-run or steal-and-hide variety. Masses of people, men, women and children, were camping in the heart of the forest like victors or desperados, cutting, drying, bundling, and carrying away the grass, unhurried and unafraid. The men folk were armed with bows and plenty of arrows, the women formed formidable stone-throwing squads, but what the trailing kids did or were recruited for, the report did not say. The dutiful forest subordinates had already been pelted with blood-taking boulders of the Deo river whose winding course was the marauders' stronghold.

Far away from the Deo, in the far off official domains, these reports stirred up panicky visions of subversive politics. Tentative whispers floated in the air of uprisings of the dreaded sort, of forest *Satyagraha*, etc. A Civil Department official who had been sent out on secret enquiry into the roots of the reported manifestation returned with desperate tales of organized defiance, of mass scale looting, of something he from loyalty feared to tell. So two days prior to the neighbouring *hāt* day a magistrate and a lorry load of fully armed police journeyed with the Divisional Forest Officer into the forest. The magistrate had been meticulously coached up by the superior official in strategy—that to haul in a big net of the looters the party must camp at a distance from the Deo, that secrecy of move should be the watchword.

Information was taken from the camp. Yes, a big body of the *sabai* looters were duly in camp along the river. Zest was added to the venture and success loomed ahead.

So the following morning we went. Walking a mile at the end of motor journey we arrived at the spot. And true to word countless *sabai* sheaves spread out on the landscape were lazily drying in the sun. They looked like the dead bodies of administration. They saddened the Divisional Forest Officer, pleased the magistrate and put the police into their own. Also, true to report there were regular camps of leaf-sheds, with straw, mats, earthen pots, and leaf cups. The camps were empty of inmates. Only in one was a women cooking. And upon her we fell (not physically). But she sat unmoved like a smiling rock and to our angry questions of why and whereabouts she gave airy answers of unconcern tinged with surprise. Her features seemed to say that we were the intruders, not she and her folk. Meanwhile she went on stirring the boiling rice with a twig and with the other hand feeling the infant by her side. But when the red-turbaned constables came to her view her features and poise instantly changed—the twig dropped into the pot, the smile gave way to a piteous twist of the lips, the eyes moistened and both her hands clutched the kid who had been startled into bursting cry. We assured her we meant no harm to her personally. Immediately we noticed two men darting out from another leaf-hut hid in the bushes, rushing across the shallow Deo and disappearing in the forest up hill. A whistle was also sounded by one of them. This was a muster call to the comrades who were dispersed in the woods cutting more *sabai*. A war atmosphere suddenly enveloped us. The Deo murmured by. The hill stood quiet. Only an occasional dry leaf wafted by the spring breeze made an audible sound as it touched the ground.

After some time a few of the men arrived. And immediately we fell upon them (physically this time). But no, they were not the fearsome pugnacious people we had pictured, but perfectly docile. Even more than that, they were thoroughly miserable, famished, a

picture of hunger and want. Hunger and want had done all they could to kill these neglected men. It was the spirit of the woods that kept them alive. The soul that resides in the noble sal, in the deathless stream, in the mighty crag at the hill-top, that soul made these people immortal.

The explanation of the supposed political upheaval was simple. These men had always depended upon *sabai* trade to supplement the meagre yield of their paddy land—they bought *sabai*, made it into string and sold it on Saturdays at Tonto *hāt*. The *sabai* lessee was under contractual obligation to sell *sabai* from his depots at fixed rates to the local people, but lately *sabai* price had soared up and the lessee had defaulted in greed. Seeing no alternative (to them the local agent is the ultimate authority) and driven by hunger and the hunger of their children they had themselves started cutting and removal. "We each have the money to pay the price", they said "but the depot agents will not give without realizing heavy extras". And the days were distressful beyond endurance. There was a crushing rice famine in the country. Their own little paddy had suffered from drought and depredation of wild elephants. For days and weeks they and their children subsisted on roots, fruits and leaves of the forest. Even the *sabai* trade gave them very little—it took almost the entire week to do a deal. Yet this was their only support.

To regularize the matter we asked them to come to the Forest Rest House. And thither they came, late in the dark evening, a long dismal line of them, wearily pacing the dusty road and curving with it, feeble old men with steaming shoulders, women balancing suckling babies with their load, even children of ten with weights beyond them, each with a *sabai* sheaf, big or small, in head loads or shoulder, the plaited ends trailing like the mournful maiden's locks. Fire-flies flitted about in and out. The Deo in its downward course still murmured. Village dogs barked. A bird in the distance kept up its monotonous note.

Some of the people had a meal in the morning. Many had no meal at all that whole day, their stock of rice having run out. Under the tree in the Rest House compound, in the faint light of the lantern the children, disengaged from their loads, peered at us with hollow eyes. I asked when they had eaten. "Nothing since the morning", said the mothers from all directions. My inner being revolted against the sumptuous dinner that I had eaten. But that was beyond mending. Whatever was in the kitchen for the servants was put together and the children were fed. The others could not be helped. Nor was there enough sheltered abode or firewood for them. Under the sparse shade of the tree, open to the cold breeze, with a miserly fire in the middle, those poor people, with hardly any cover, lay to pass the night. It was only my hardened conscience that put me to sleep in my soft warm bed.

The following morning I motored to the *sabai* depot to release the stock. On one side were two boys standing and intently watching. One was about ten, the other eight years old. Both had the belly bulging with spleen, chest hollow, ribs protruding and eyes pale. There was hardly any cloth on them.

"What is your name" ? I asked.

"Maka" replied the elder.

"And yours" ?

"Ladu" squeaked the younger shyly.

"And what have you eaten" ?

"What have we eaten ?", pondered the elder ; "nothing".

"When will you eat then" ?

He indicated with his finger a point in the sky where the sun generally reaches at three in the afternoon.

"And what will you eat" ?

"What shall we eat ?", pondered the elder again ; "anything that we get—leaves, roots, wild fruits, etc.".

"But to-day is Saturday" broke in the younger almost leaping from behind, temporarily conquering his shyness. There was a wistful look of pleasant longing in his face.

"What of that ?", I asked in surprise.

"To-day is Saturday", he began explaining, "father has gone to Tonto *hāt* to sell *sabai*. He will bring rice. This night we shall eat rice".

My heart sank within me. We had cared so much for the grass and the trees. But what had we done for these children of the trees ?

My mind went to the rich business magnates, many of whom have fattened on these forests, and to their drink-and-play club. They too wistfully long for Saturday night. But what a difference !

AFFORESTATION OF HILL SLOPES OF JANJIRA

BY L. P. MASCARENHAS
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In the *Indian Forester*, March 1938, I had written an article on the Forests of Janjira State and the method adopted to stock the hill slopes denuded of all tree growth in order to check the erosion which was going on from the time *Kumri* cultivation was started all along the hill slopes on the West Coast from Bombay southwards. Travelling by the daily coastline steamer during the fair weather one could see that heartrending sight of the hill slopes which were once clad with rich vegetation but now quite bare and devoid of all tree and even shrubby growth. Having retired from the Mysore Forest Service in January 1934, I was soon appointed as Chief Forest Officer of the Janjira State where I worked for 4 years. My main job during this period was to afforest the bare hill slopes. Until 1860, the Janjira Chiefs took great care of their forests by forbidding export and severely punishing timber thefts and injury to forests. Since then, for nearly six decades, all the unreserved forests locally called '*Kirdawas*' were subjected to wholesale destruction on account of uncontrolled *tahal* lopping, indiscriminate cutting of valuable trees for house building and agricultural implements and collection of firewood faggots for supply to villages and important towns and, most important of all owing to the ruinous system of shifting cultivation.

The marked effect of indiscriminate deforestation is that the rainfall instead of slowly sinking into the ground and without being absorbed rushed off in destructive torrents which excavate for themselves deep ravines, carry down large quantities of debris and after covering low-lying areas of the country with injurious material, passed uselessly into the sea. Land which used to produce crops has been covered with sand, good soil has been carried away by the erosion of torrents and the level of water in the wells has sunk to an alarming extent.

About the year 1925 the State authorities realized the importance of introducing regular management of both the reserved and unreserved forests and the need of a progressive but nevertheless conservative policy.

Composition and condition of the crop.—The forests of Janjira are of two kinds :— (1) *Reserved forests :* containing teak growth with an admixture of *Terminalia paniculata, Terminalia tomentosa, Terminalia chebula, Bombax malabaricum, Grewia tiliæfolia* and *Gmelina arborea* and (2) Unreserved forests : with poor growth of *Terminalias.*

I introduced the Mysore system of trench and mound sowings, which has been in vogue there from the year 1930 and which had given good results in the *maidan* forests of that State. The system consisted of digging small trenches suitably distributed along the contours to catch rain-water, silt and humus, check erosion and improve the fertility of the soil.

(2) On gently sloping ground, interrupted trenches 48′ long $1\frac{1}{2}'$ broad $1\frac{1}{2}'$ deep were dug along the contours and the trenches of successive rows alternated with one another as shown below :

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(3) The distance between the trenches and between rows of trenches may be kept at an uniform espacement of 24 yards.

(4) As *Cassia* and *Karanj* are two excellent hosts of sandal which withstand well the root parasitism of sandal, these species were mostly used with an admixture of sandal.

In the last para of my article referred to above, I had stated that during the 4 years of my stay 3,200 trenches of the above dimensions were dug and some mounds sown with *Cassia* and sandal, some with *Karanj* and sandal and some with *sissoo* and sandal, some with *siris* and sandal and some with pure cashew-nut only ; but *Tephrosia candida* and mango were sown inside the trenches. During the dry season tender shoots of *Tephrosia* were greedily devoured by cattle. The trenches were dug by the end of December before the ground got dry and sown just before the next monsoon started. After I left the State in 1938, this work was continued and the Forest Officer-in-Charge was kind enough, as per my request, to give the measurements of the species for the years 1943 and 1949.

Name of locality	Distance from sea-coast in mls.	Year of sowing	Cassia 1943		Cassia 1949		Sissoo 1943		Sissoo 1949		Sandal 1943		Sandal 1949	
			Average height	Average girth	Average height	Average girth	Height average	Girth average	Average height	Average girth	Average height	Average girth	Average height	Average girth
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Kamgoan ..	11	1934	25	18	30	22	12	10	17	15	18	10	22	16
Chirgoan ..	8	1934	27	21	32	25	10	10	13	13	15	12	20	16
Ghonsa ..	8	1934	26	18	32	22	10	9	13	12	18	12	22	16
Kelta ..	5	1934	25	15	30	20	9	9	13	11	12	10	16	14
Galsure ..	4	1934	25	14	30	20	12	10	17	13	18	12	22	16
Kandna ..	4	1934	27	15	32	25	10	9	13	12	15	12	20	16
Chorda ..	2	1934	20	18	25	22	9	8	12	11	20	15	24	18
Borlai ..	1	1934	21	18	32	24	15	12	30	28	18	12	21	16

From the above statistics, it can be seen that sandal does grow well along the sea coast with an admixture of suitable host plants. The Forest Officer now in charge of the forest, states that sandal has acclamatized itself, that it is common to see different stages of natural regeneration of sandal under the bushes which is, therefore, more successful than the indigenous species.

This system can be tried by the Bombay Forest Department on an experimental scale to afforest the bare hill slopes all along the West Coast. A peep into the Janjira forests will convince the officers of the results achieved.

In this connection, I should like to draw the attention of Forest Officers to an article "Sandalwood at sea-level" of March 1908 by late Mr. M. Rama Rao of the Madras Forest Department.

A NOTE ON ITALIAN OLIVES

BY C. QUIEN AND F. J. HOPMAN

Type : *Oleineæ, Kind, Oles L.*

Species : *Olea Europea.* Subspecies : *Olea Europea* L. *Oleaster.*

Species : *Olea Europea L. Sativa (var. cultivated).*

Height of the Plant : 15 to 60 feet.

Locality.—(*a*) This plant is typical of the Mediterranean basin. It is, however, also cultivated in other parts of the world (such as Argentine, Australia, etc.), although the qualitative production is less excellent.

(*b*) The natural geographical limitations are, therefore (although not absolutely) 20° Long. East of Paris and 45° Long. East of Paris ; 46° Lat. North to 29° Lat. North.

(*c*) The quantity in which it can prosper varies according to the latitude and, therefore, the climate (from plains to real mountains).

(*d*) It is sensitive to excessive frost (under 7 degrees Celcius) especially if prolonged for 8 to 10 days, or to frost changing with mild temperatures (it does not resist great and sudden changes in temperature). It can bear heat and dryness if not excessive.

(*e*) It germinates 10° to 11° Celcius, the blossom buds at 15°C. It blossoms at 18°–20°C. The forming of the fruit take place at 21°–22°C (annual medium of 15°–20°). It generally grows in places characterized as Mediterranean climates.

(*f*) It grows in almost all soils that are normally cultivable or under cultivation (which have the above mentioned climatic conditions, unless too *damp* or *compact*, even if of very rich base).

TECHNIQUE FOR CULTIVATION

Having to plant the olive grove at a great distance from the place which supplies the planting material it is advisable to order plants which are roughly two and a half years old. These should be placed in a nursery in the same zone in which they will afterwards be transplanted. The transplanting takes place after two years when the plants have been acclimatized.

It may be advisable also to use the wild olive for grafting purposes or to sow seeds from cultivated plants in those areas where wild olive grows naturally (as is the case in certain parts of the Himalayas for instance in the Jehlum valley near Uri).

In other zones one should experiment with the planting of cuttings or slips with reproductive capacities (in which case one would avoid grafting and be able to obtain plants similar to the mother plant). One cannot say off hand whether reproduction of plants from seed or from cuttings is to be preferred. One can only think that outside their natural climatic zone, wild grafted olives would be less resistant to unusual climatic or parasitic conditions and, therefore, planting of cuttings with reproductive organs of the domestic kind should be preferred.

However, whichever method one decides on will depend on the availability of one or the other kind of planting material.

When choosing domestic varieties it is important to keep in mind that 'Moraiolo' is the most resistant to low temperatures (Kashmir valley, Niligiris), other varieties are 'Frantoianao and Leccino'.

The young trees should be planted in the nursery in rows which are 4 feet 6 inches apart. The plants in each row should only be 1 foot 6 inches apart. In this nursery the soil will be worked, manured and, if necessary, irrigated.

When transplanting the olive grove from the nursery, one will have to reckon about 100–150–200 trees to one hectare (about three acres) according to whether one expects the trees to develop and grow more or less and also bearing in mind the steepness of the slope so that each plant will have a minimum of light.

Before transplanting the trees, the following work is essential—

(*a*) fencing in the area.

(*b*) weeding it, clearing out roots and stones.

(*c*) setting up an irrigation system, regulation of surface and underground waters, division of the ground into sections. All this is necessary if one wants a promiscuous cultivation (in Italy wheat vegetables and vines are planted amongst the olives). It is *necessary* to terrace the ground in accordance with the steepness of the ground. This is of the greatest importance in order to preserve the top-soil and economize on the fertilizing material used.

(*d*) With regard to pruning; it is not easy to explain the method of executing this agricultural practice and we will, therefore, for the present omit its description. One should, however, keep in mind the shaping of the trees first for growth and later for production the trees are kept vase shaped with conical branches.

The work done in the olive groves is the autumn or spring plowing and plowing under of fertilizing material and the summer howing.

Although one would not want to treat the trees for all their parasitical enemies, both animal and vegetable as these are too numerous, it should be pointed out that is essential to give the copper sulphate treatment of one and a half to 2% during April or May and August to September.

THE CULTIVATION OF DOMESTIC OLIVES TRANSFORMED FROM WILD GROVES

Work to be carried out :—

(*a*) Choice of wild olives most suited to grafting according to the condition of the soil, condition of the plants, state of growth and development.

(*b*) Fencing in.

(*c*) Eventual weeding clearing of roots and stones, chopping down of useless wild olives or other obstacles.

(*d*) Setting of an irrigation system (as for the cultivated olive groves).

(*e*) Transplanting of the wild olives to more suitable places so that a better distribution of the plants is made.

(*f*) Means of access.

(*g*) Grafting of the wild olives with slips of the domestic varieties (generally the crown shaped grafting is done in autumn).

PRODUCTION

The gradual harvest takes place from October or November to February and March. The ripe fruit is black-violet on the outs.de and red inside.

The crop varies notably from one plant to the other in the same zone and varies even more from one zone to another, this depending on many factors, the development of the plant, ecology in kind, etc.

The plant starts production from the earliest years, say 4 to 6 years and the crop increases up to the age of 35 to 40 years and remaining steady for many years. Thereafter plants of 100 or 200 years bear fruit up to 400 years.

An adult plant of medium development can supply *10 to 20 lb. of olives.* The production of oil from the olive varies from 14% to 27%.

An adult plant of medium size produces for several hundred years 11 to 12 ounces to 2 or 3 lb. of oil yearly. These are average figures. There are plants that give as much as 20 lb. of oil a year.

EXTRACTION OF THE OIL

One needs a modern installation of relatively small dimensions ($m \cdot 2 \times 1 \cdot 5$) known as Clamicola made by the Firm Galardi. In addition one needs the kind of press that is most easily transplanted and otherwise suitable.

Note :—The above information refers only to the cultivation of olives in areas similar to the Italian province of Tuscany.

The Societa Pesciatina d' Orticoltura, Florence, Italy can supply the trees at following prices :—

Grafted Olive, two and half years old (one year after plantings) 90 to 100 lire (1 pound sterling = 1735 lire).

Grafted Olive, about 3 years old (with pole attached) 300 lire (good for experiments regarding suitability of districts).

These prices can be lowered in the case of large orders. These plants are produced from grafts derived from seeds, etc., of the domestic varieties above mentioned.

The same company can also supply grafts (slips) of domestic varieties suitable for grafting on wild olives.

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Olives are planted in Italy jointly with other crops such as wheat, vines, vegetables and fodder. Owing to the fact that they cast very little shadow and are evergreen, crops planted under them rather improve than otherwise.

Irrigation is only required as long as the trees are very young.

FOREST WEALTH OF GIR AND GIRNAR IN JUNAGADH DISTRICT OF SAURASHTRA

BY PROF. G. A. KAPADIA

According to the Bombay Gazetteer the area of the Junagadh Gir was something like 1,200 sq. miles in 1878. The present Gir forest with its area of 495·4 sq. miles is what now remains of this once most valuable forest. The area of the forest lands under the management of the Forest Department amounts to 565·65 sq. miles which is nearly one sixth of the area of the then Junagadh State. It is essential for the State to have at least 20% of its total area under forest from the view-points of climate and economic wealth.

The physical aspect of these forests is very rugged and broken. Hills over hills extend from one end to the other. The hills are as a rule low with an altitude of less than 1,000 ft. and they have moderate slopes, though here and there occur steep inclines. Nandivelo is the highest hill in Gir having 1,741 ft., above the sea. Gorakhnath with 3,666 ft. is the highest hill in Girnar forest. The entire tract is cut up by numerous streams, both large and small and which feed the seven principal rivers namely the Hiran, the Shingavada, the Machhundri, the Saraswati, the Jhateri, the Rawal and the Malan. These hills consist of rocks known as trap and basalt. The soil is extremely variable both as regards depth and composition. The soil layer has very little or no depth on the slopes of hills ; but the valleys and the plain regions of the forest have considerable depth of rich black soil. These forests are markedly deficient in humus. It is present only in the regions along the banks of rivers and water courses.

Vegetation of the forest depends on various factors such as rainfall, climate, soil, etc. These forests belong to the deciduous type in which most of the trees are leafless for a portion of the year. The number of individual species of trees, etc., comprising the forest wealth is very considerable. Unfortunately there is no detail record of our forest flora. Besides this there is no record of the statistics of the forest products both major and minor.

The major forest products are timber, firewood and bamboos. Of the timber crop teak is the principal species. The growth of the teak trees in these forests, is poor in girth and in height. Besides teak there are other useful timber trees.

Systematic list of timber trees is given below :

1. Fam. ANONACEÆ.
   1. *Polyalthia cerasoides* Benth & Hook.
2. Fam. TAMARICACEÆ.
   2. *Tamarix gallica* Linn.
3. Fam. MALVACEÆ.
   3. *Bombax malabaricum* Dc.
4. Fam. STERCULIACEÆ.
   4. *Sterculia urens* Roxb.
   5. *Grewia tiliæfolia* Vahl.
5. Fam. RUTACEÆ.
   6. *Aegle marmelos* Correa,

6. Fam. SIMARUBACEÆ.
   7. *Ailanthus excelsa* Roxb.
   8. *Balanites roxburghii* Planch.

7. Fam. MELIACEÆ.
   9. *Azadirachta indica* A. Juss.
   10. *Soymida febrifuga* A. Juss.

8. Fam. RHAMNACEÆ.
   11. *Zizyphus jujuba* Lamk.
   12. *Zizyphus xylopyra* Willd.

9. Fam. SAPINDACEÆ.
   13. *Sapindus laurifolius* Vahl.

10. Fam. ANACARDIACEÆ.
   14. *Mangifera indica* Linn.
   15. *Odina woodier* Roxb.

11. Fam. LEGUMINOSÆ.
   16. *Erythrina suberosa* Roxb.
   17. *Butea frondosa* Konig.
   18. *Dalbergia latifolia* Roxb.
   19. *Pterocarpus marsupium* Roxb.
   20. *Pongamia glabra* Vent.
   21. *Cassia fistula* Linn.
   22. *Prosopis spicigera* Linn.
   23. *Acacia arabica* Willd.
   24. *Acacia leucophlœa* Willd.
   25. *Acacia catechu* Willd.
   26. *Albizzia lebbek* Benth.

12. Fam. COMBRETACEÆ.
   27. *Terminalia catappa* Linn.
   28. *Terminalia bellerica* Roxb.
   29. *Terminalia tomentosa* Wight & Arn.
   30. *Terminalia chubula* Retz.
   31. *Anogeissus latifolia* Wall.

13. Fam. MYRTACEÆ.
   32. *Eugenia jambolana* Lamk.

14. Fam. RUBIACEÆ.
   33. *Adina cordifolia* Benth & Hooker.
   34. *Stephygyne parvifolia* Korth.
   35. *Hymenodictyon excelsum* Wall.
   36. *Randia dumetorum* Lamk.
   37. *Morinda tinctoria* Roxb.

15. Fam. SAPOTACEÆ.
   38. *Mimusops elengi* Roxb.
   39. *Mimusops hexandra* Roxb.

16. Fam. EBENACEÆ.
   40. *Diospyros melanoxylon* Roxb.

17. Fam. OLIACEÆ.
   41. *Schrebera swietenioides* Roxb.

18. Fam. APOCYNACEÆ.
   42. *Holarrhena antidysenterica* Wall.
   43. *Wrightia tinctoria* R. Br.
   44. *Wrightia tomentosa* Roem & Schult.

19. Fam. BORAGINACEÆ.
   45. *Cordia rothii*, Roem & Schult.

20. Fam. BIGNONEACEÆ.
   46. *Tecoma undulata* G. Don.

21. Fam. VERBENACEÆ.
   47. *Tectona grandis* Linn.
   48. *Gmelina arborea* Roxb.

22. Fam. EUPHORBIACEÆ.
   49. *Bridelia retusa* Spreng.
   50. *Phyllanthus emblica* Linn.

23. Fam. URTICACEÆ.
   51. *Holoptelea integrifolia* Planch.
   52. *Fiens bengalenses* Linn.
   53. *Ficus glomerata* Roxb.
   54. *Ficus religiosa* Linn.

The timber of these plants can be put to so many varied uses such as construction and general carpentery work, ship building and carriage building, turnery, manufacture of mathematical instruments, pencils, penholders, bobbins and shuttles, matches and match boxes, plywood, brushes and agricultural implements.

Next in importance to the timber species comes the species of grasses. The fodder grasses are of immense importance as furnishing food for animals. A few of the grasses have somewhat active properties and are esteemed as medicinal.

Grass lands are a conspicuous feature and especially of Gir which is the biggest headquarters of the *Ghee* making industry in Saurashtra. They come under the general ecological type of Savannah.

The principal members of the Savannah association are *Ischœmum rugosum* Salisb., *Apluda varia* Hack., *var aristata* Hack., *Dichanthium annulatum* Stapf, *Eremopogon foveolatus* Stapf, *Cymbopogon martinii* Stapf, *Heteropogon contortus* Roem & Schult, *Themeda quadrivalvis* O. Kuntz., etc.

Most of the grasses serve as fodder. Of these *Ischæmum pilosum* Hack., *Sehima nervosum* Stapf, *Dichanthium annulatum* Stapf, *Eremopogon foveolatus* Stapf, *Andropogon pumilis* Ritz., *Isiliema laxum* Hack., *Themeda quadrivalvis* O. Kuntz., *Brachiaria Isachne* Stapf., *Cynodon dactylon* Pers. and *Eleusine indica* Gaertn. are considered as good fodder.

Dendrocalamus strictus Nees. is the only gigantic species of grass. This strong elastic bamboo is put to most varied commercial uses ranging from the common domestic articles to building purposes, matting and basket work, walking sticks, *lathis*, lance shafts, punting poles, furniture, manufacture of paper pulp, etc.

These forests are exceptionally rich in a large number of minor products. Possibilities for the manufacture of paper pulp from bamboos and grasses are very favourable. Tanning materials from barks, fruits and leaves are available. Certain aromatic species occur, from the distillation of which valuable scented oils are obtained. Fatty oils can be obtained from seeds of certain forest trees. With the exception of *Schleichera trijuga* Willd., all other trees on which lac grows are available in these forests. *Acacia catechu* Willd., is also available. These forests are rich in herbs, shrubs and trees which have actual or potential value for medicinal purposes. Honey is also one of the minor product.

EXPERIMENTAL AFFORESTATION OF DENUDED HILL-SIDE AT LOW ELEVATION (NURPUR-KANGRA)

BY MALIK KHEM CHAND MALHOTRA,
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I. INTRODUCTORY

Destruction of natural vegetation over submontane tracts (foot-hills), as a result of unrestricted grazing, browsing and cutting of wood and bushes, is wide-spread throughout the Punjab. And the consequent serious erosion has given rise not only to the loss of valuable soil but also to abrupt and uncontrolled floods in the torrents fed by drainage from those tracts. The deterioration in the plant cover, which is most pronounced near habitations, thus constitutes a menace to the prosperity of both the rural and urban population whose resources of the jungle are depleted, whose farm-yard manure is diverted from fields to hearths and whose fields are not only deprived of the sub-soil moisture but are also ruined by erosion and floods.

2. The value of forest as a stabilizer of climate and other conditions of land has not been fully realized. The stark necessity of trees and forests for the economic well-being of particularly the rural population is also not fully appreciated, and nor is the fact that erosion control and sub-soil water conservation and supply are greatly aided by forest cover. Hidden virtues are always harder to see. Accordingly, forests have been looked upon, particularly in India, merely as a source of profit by individual owners and communities, as well as by rightholders, to be tapped as quickly as possible and to be later neglected and forgotten, unmindful of the serious consequences accruing to themselves from their own mischief.

3. The Tennessee Valley Administration's activities in the United States of America have demonstrated beyond all doubt the vital necessity of national planning to include proper utilization of soil and of the conservation of forest cover, specially on hill-tops and foot-hills. On similar lines, far-reaching scheme for the control of the Damodar river floods have been prepared by the joint labours of the Governments of India, Bengal and Bihar, as per the extract : "Afforestation and anti-erosion measures have been given a high place in the scheme. While the experts differed in other methods, such as the type and location of the dams and other engineering problems, it was the unanimous opinion of the Damodar flood control committee that it was absolutely indispensable that the upper catchment area must be brought under scientific management which will include not only regulation of fellings, grazing and cultivation, but also afforestation and construction of small earthen bunds, plugging of gullies and various other anti-erosion measures, such as contour ridging and bunding".

4. The part which vegetation plays in holding up run-off, etc., needs to be fully realized. And this aspect of the usefulness of forests and foresters has to be brought home to the public, as contributing, in no small measure, to general human economy and prosperity. Besides, the afforestation measures are not only an answer to the domestic and industrial needs for grass (fodder and economic), firewood (a double-barrelled produce both as fuel and as a means to release cow-dung for improving output of food crops by at least 15%) and timber (both for constructional purposes and agricultural implements), but will also afford to the public park lands, groves and avenues for recreation and smiling landscapes as Nature's graceful compliment to human wisdom, and thus hallow the State with a halo of glory.

5. Hence, for purposes of experiment and demonstration as to the possible measures for arresting the process of erosion in an advanced stage for retarding run-off by rehabilitating dense forest cover through natural regeneration by protection (closure), supplemented by afforestation, and by gully control, a research station was started over a typical plot (Designated as Experimental Afforestation Plot No. 4) of 37 acres (in two adjacent plots of 29+8 acres) of denuded and badly eroded hill-side near Nurpur (Kangra district) in 1934 (main block) and 1941 (smaller block and successfully terminated in 1947. The result of 14 years' investigations are dealt with in this Note.

II. DESCRIPTION OF THE EXPERIMENTAL AFFORESTATION PLOT (No. 4)

6. *Situation and Extent.*—The plot lies in D.P. Nurpur-Compartment No. 2, on the left bank of the jabar torrent to the North-West and below the motor road forming its South-Eastern boundary, close to Nurpur town, Kangra district, at the foot-hill in Kangra valley, in two adjacent blocks of 29+8 acres taken up in 1934 and 1941 respectively.

7. *Topography.*—Slope is seldom of even gradient and varies from moderate to steep ; but the ravines have vertical sides with dangerous precipices. And the surface configuration is always everywhere irregular and rugged with westerly aspect.

8. *Geology and Soil.*—There are two geological formations over the area, viz., sandstone and boulders, and the soil is shallow loam impoverished by denudation and erosion, with red marl, clay, gravel and lime nodules at places.

9. *Climate.*—It is a bit milder than the typical Punjab climate, but yet extremes are experienced ; and frost occurs occasionally. The average annual rainfall is 56″, but erratic and unevenly distributed, occurring as it does in a short series of monsoon storms after which the locality is parched for many months mitigated to a varying extent by gentle winter rains which are at best unreliable. There is scarcity of water for man and cattle both.

10. *Resultant Vegetation and Erosion.*—On account of the close proximity of Nurpur town, the area had been subjected to heavy grazing and lopping and unrestricted cutting of wood in the past. This resulted in more or less complete denudation and severe sheet and gully erosion of the area, with the resultant impoverishment of the soil. The tree vegetation became scarce and stunted, except along the nullahs. Of the grasses, only the coarser (inferior) varieties survived to form a poor and sporadic ground-cover. The erosion debris was swelling the torrent below. The surviving sporadic, stunted vegetation comprised of *Dalbergia sissoo* along nalas, *Acacia catechu* in escapes, a sprinkling of *Cassia fistula* on bouldery deposits, *Wendlandia exserta* on land slips and scattered and heavily browsed bushes of *Carissa spinarum* on spurs. *Nyctanthes* and *Themeda*, indicators of impoverished soil, were met with in the southern extremity, and *Adhatoda* and *Bothriochloa*, the last remains of a worn out foot-hill pasture, in the north near the habitation. Occasional and cut-back *Dodonea* was also visible. The area was thus so bare that adequate shelter for under-planting or dibbling of seeds was not available ; and consequently, many trials at afforestation failed.

III. THE EXPERIMENTS

11. *General.*—With a view to wholly rehabilitate the plot by experimental remedial measures for reafforestation and anti-erosion, the investigations undertaken embraced the following projects :—

12. *Closure.*—For facilitating and safe-guarding the reafforestation and stabilization of soil, the main block of 29 acres was closed to grazing and browsing, and rights of the populace

were suspended in 1932 for a period of 10 years, under Punjab Government notification No. 2544/G dated : 17-6-32, which was later extended by another 5 years under Government notification No. 3246/Ft., dated : 25–10–41. The closure was, however, actually enforced in 1934, and was availed of for 14 years up to 17–6–47. The smaller adjacent block of 8 acres was likewise closed in 1941 for 10 years—vide Government notification No. 3167/Ft., dated : 16–10–41. To render the closures effective, the whole plot was fenced round with barbed wire. No undue restrictions were, however, imposed on the local populace. For instance, they were allowed to cut dry and fallen trees and also grass throughout the year except during the growing monsoon season.

13. *Natural regeneration.*—As a result of the closure, and the consequent ecological succession, spontaneous growth of grasses, herbs, shrubs and trees came up gradually, starting wherever the soil had not so deteriorated as to be completely deprived of its capacity for sexual and vegetative reproduction. The vegetation, in turn, gradually stabilized and improved the soil all over ; while the latter, in turn again, attracted extension of the former. This mutual-improvement circle, supplemented by artificial aid in planting (dealt with hereafter), eventually resulted in the prevention of erosion and establishment of the desired plant cover. The natural regeneration included the following species :—

(i) *Trees.—Dalbergia sissoo, Wendlandia exserta, Acacia catechu, Ehretia aspera, Ougeinia delbergioides, Albizzia lebbek, Cassia fistula, Grewia oppositifolia, Thevetia neriifolia, Cratæva religiosa, Butea frondosa, Trema politoria, Zizyphus jujuba, Acacia arabica, Flacourtia ramontchi* and *Bombax malabaricum.*

(ii) *Shrubs.—Carissa spinarum, Dodonea viscosa, Nyctanthes arbortristis, Adhatoda vasica, Euphorbia royleana, Mimosa rubicaulis, Gymnosporia royleana, Colebrookea oppositifolia, Zizyphus fruticosa, Indigofera hirsuta,* and *Murraya kœnigii.*

(iii) *Herbs.—Lespedeza sericea, Rhynchosia minima, Crotalaria modicagines, Argyrolobium reseum, Indigofera anabaptista, Desmodium gangeticum, Cassia tora, mimosoides* and *dimidiata* and *Achyranthes aspera.*

(iv) *Climbers.—Atylosia scarabœoides* and *Puraria tuberosa.*

(v) *Grasses.—Dichanthium annulatum, Bothriochloa pertusa, Chrysopogon montanus, Themeda anathera, Heteropogon contortus, Apluda aristata* (perennial variety) and *Cynodon dactylon* (common due to clay soil).

(vi) *Sedges.—Eriophorum comosum.*

14. *Artificial reproduction.*—The inimical climatic, edaphic and biotic factors, creating highly unfavourable conditions for the establishment of the requisite tree cover, called for artificial aid. The erratic rainfall and its uneven distribution, leading to drought spells or crowding of precipitation in a few abnormal and sudden storms, could not spontaneously make the generally sterile, unabsorptive, exposed subsoil bear tree growth on a wide scale. Therefore, likely suitable species of trees, etc., had to be experimentally tried, and the best technique for propagation of the successful ones evolved. In the choice of species, the essentials kept in view were the silvicultural requirements, the inimical factors of locality, rapid growth, and ease of cultivation and soil conservation. In all 58 species were tried under various methods of propagation, site-preparation and moisture-conservation. Appendix

gives results of the important ones. And the results of those found quite successful for the purpose are tabulated below :—

Species	Method of propagation	Year of trial	Success percentage in 3/47	Average height in 3/47
				feet
Acacia arabica	Patch sowing	1935	33	14
Acacia catechu	Trench and patch sowing (mostly in nullahs)	1936	100	12
Acacia modesta	Trench sowing	1938	100	8
Agave cantala	Hole planting (on steep eroded slopes) ..	1935	70	6
Anogeissus latifolia	Ball planting under shelter of bushes ..	1938	50	2½
Butea frondosa	Patch sowing	1935	100	10
Do.	Trenching sowing	1936	100	9
Dodonæa viscosa	Broadcast sowing on eroded slopes ..	1935	very good	7
Do.	Patch sowing	1936	100	9½
Grewia elastica	Pit planting under shelter of bushes ..	1938	31	11
Prosopis juliflora	(Argentine) Ball planting (potted plants)	1938	60	19
Do.	(Arid) Trench sowing	1936	100	10
Do.	,, Patch sowing	1936	60	14
Do.	,, Ball planting (potted plants) ..	1936	43	20
Do.	(Australian) Trench sowing	1936	100	17
Do.	,, Patch sowing	1936	75	5
Do.	,, Ball planting (potted plants)	1936	36	10
Do.	(Mexican) Trench sowing	1936	50	20
Do.	,, Patch sowing	1936	94	16
Do.	,, Ball planting (potted plants)	1936	36	24
Do.	(Peruvian) Trench sowing	1936	100	9
Do.	,, Ball planting (potted plants)	1936	80	23
Rhus lancea	Ball planting (potted plants) ..	1936	100	12

15. *Gully plugging.*—While avoiding costly engineering works, 28 Check dams of rubber masonry (with wire netting over 7) were constructed in 1937 in the 4 streamlets (nullahs) under active gully erosion ; and they proved efficacious enough in regulating the flow of storm water by delaying the run-off, in raising silt-terraces in the ravines, in increasing moisture for vegetation and in stabilizing banks.

16. *Erosion statistics.*—A battery of erosion trays, along with a rain-guage, was installed on 9-7-37, and discontinued on 30-6-41 after collection of data about the pace

of erosion of soil under various kinds of plant cover, by which time the entire soil had been washed out of the trays having no vegetation cover, leaving behind only a mantle of pebbles. The battery consisted of equal-sized trays full of equal quantities of similar soils bearing the following 3 different types of cover and all fixed on 1-in–4 slope :—

(i) Bushes (*Carissa* and *Adhatoda*).

(ii) Grass.

(iii) Naked (no vegetation cover).

The quantity of soil lost in erosion and of the rain-water absorbed during the period of 4 years are tabulated below :—

Particulars	Grass cover	Bush cover	Bare soil
Percentage of rainfall which ran off on 274 wet days (total rainfall = 138·37″)	8	10	56
Absorption percentage	92	90	44
Weight (in lbs.) of soil lost per acre during the 274 wet days ..	7,408	8,034	91,808
Annual loss of soil per acre	1,852 lbs.	2,009 lbs.	22,952 lbs.

The table indicates clearly the relative efficacy of the various types of plant cover for conservation and water-absorption of soil.

17. *Demonstration*.—With a view to demonstrate the results of experiments to the public, for purposes of education and propaganda, the Plot was designated as "Public Park", a board put up at the entrance on the town side, wide publicity given, well aligned paths made and maintained throughout the Plot for easy access and stroll, wooden benches provided at suitable places for rest and recreation and restrictions eliminated to the minimum compatible with protection which was maintained efficiently by patrol and maintenance of the fence. The right holders were allowed to cut grass for 9 months in the year, and also allowed to remove dead and fallen trees.

IV. RESULTS

18. The Plot is now completely reclaimed, vegetation (grasses, bushes and trees) fully rehabilitated and erosion prevented in toto. It has served as a good example and demonstration of what can be achieved by simple and cheap devices of closure, gully-control and planting. The interrupted contour trenches prevented surface run-off and conserved moisture, thereby preventing sheet-erosion and facilitating bringing back of vegetation ; and so did the gully plugging against gully-erosion. Closure improved the soil and brought in, and protected, natural as well as artificial reproduction. The results will be valuable for purposes of publicity also.

19. The future management of the area should be so designed as to prevent repetition of sad state of affairs. Thickets of trees here and there need cleanings and thinnings. The mesquite (all species and varieties of *Prosopis*) should be looked after for seed production. The barbed wire fence has been dismantled.

APPENDIX

SPECIES TRIED IN EXPERIMENTAL AFFORESTATION PLOT NO. 4 AT NURPUR

Acacia arabica.—Line sowing, patch sowing and transplanting were tried. The line and patch sowings gave 20 to 25% success ; while transplanting was a complete failure. Frost damage also occurred. This species is not quite suitable for the locality.

Acacia dealbata.—Seed sown in 65 patches 2′ × 2′ during August, 1935, kept on germinating till March, 1936, in 44 patches ; but all the seedlings died subsequently. The elevation of Nurpur is lower for this species.

Acacia catechu.—Seed sown on berms of trenches as well as in patches, after soaking in water for 24 hours, gave 80% success. Stump planting was not successful.

Acacia modesta.—Trench sowing gave cent per cent success.

Agava cantala.—Hole planting on eroded slopes gave 70% success.

Anogeissus latifolia.—Ball planting under shelter of bushes gave 50% success.

Bombax malabaricum.—Stump planting was tried but failed.

Butea frondosa.—Sowings did well. Suitable for the area. There was some damage by frost but not of permanent nature.

Cassia fistula.—Sowing on berms of trenches under shade of bushes gave little or no success, and stumps failed altogether.

Diospyros cordifolia.—Sowing and pit planting did not give very encouraging results.

Dodonaea viscosa.—Broadcast sowing, tried over 2 acres, gave very great success. Entire planting was also successful.

Ehretia aspera.—Sowing and stump and entire planting did not succeed.

Euphorbia royleana.—Planting of cuttings (12″ long), 3″ above and 9″ below ground, gave very good results.

Gymonosporia montana.—Germination in patches and on berms of trenches was fair ; but subsequent development was poor.

Grewia elastica.—Entire planting under shelter of bushes gave good success.

Holoptelea integrifolia.—Entire planting was successful in the beginning, but later succumbed to drought.

Impomœa carnea.—Branch cuttings gave good results in the beginning, but succumbed to drought after rainfall.

Jatropha curcas.—Dibbling of seed gave encouraging results, to start with ; but drought always took a heavy toll of the species. Also, 3′–4′ long shoots of ½″ to 1″ diameter at thick end, planted in January (winter rains) into 1′ deep pits, failed.

Leucœna glauca.—Sowings gave fair germination ; but the seedlings died subsequently. Entire planting also was a failure. Stump planting was only partially successful.

Mitragyna parvifolia.—Did not yield encouraging results.

Opuntia monacantha.—Planting up of joints, 3″ to 12″ long, gave very good results. It is suitable for eroding areas where droughts are common. *Opuntia stricta* and *dillanii* were equally successful.

Prosopis juliflora.—In the Punjab, Mesquite has proved invaluable in clothing dry and bare low hill-sides in localities deficient in rainfall.

Various forms of *Prosopis juliflora,* viz., Argentine, Arid, Australian, Mexican and Peruvian, were tried, and gave very encouraging results of the various methods tried (direct sowing, entire planting, stump planting and pot planting), pot planting proved to be the best as below :—

(i) *Direct sowing.*—It was tried in patches as well as on berms of trenches $4'–8' \times 1' \times 1'$. The pods, after breaking into segments, were soaked in water for 24 hours before sowing. The results were satisfactory.

(ii) *Entire planting.*—It was a failure.

(iii) *Pot planting.*—This method was the most successful.

Pithecolobium dulce.—Sowing on berms of trenches germinated alright, but most of the plants died subsequently. Protection against drought and frost seems essential. Stump planting likewise died later because of drought.

Parkinsonia aculeata.—Not suited to the locality.

Prunus cerasoides.—The seed did not germinate at all even after soaking for 24 hours in hot water.

Rhus lancea.—Ball planting gave cent per cent success.

Thevetia neriifolia.—Sowing in the open was not so successful as under shade. Entire plants were a failure ; while root and shoot cuttings sprouted alright.

Zizyphus jujuba.—Dibbling of seed was quite successful.

Wendlandia exserta.—Ball planting proved to be the only successful method for planting up freshly eroded slopes. Seed of the species should be sown in pots in a nursery in June immediately after collection, and watering done with a fine rose can. Germination will take place in a week. By the next monsoon the plants will be fit for putting out.

THE SECOND YEAR OF FAO'S WORK IN FORESTRY AND FOREST PRODUCTS IN ASIA AND THE PACIFIC

BY M. A. HUBERMAN AND C. PURKAYASTHA*

The organizational work during the first six months after Mysore, in 1949, set the stage for providing the services during 1950, requested by the foresters of Asia and the Pacific. The program, outlined broadly in the recommendations made at Mysore, included the holding of a Technical meeting on standardization of timber, and the inauguration of the regional Forestry and Forest Products Commission. It involved the promotion of exchange of information, technicians, and students between countries. It called for co-operation with existing organizations in our fields of work. It provided for assistance to governments in strengthening their administrative machinery, their research and their training facilities. It called for laying the foundation for the Expanded Technical Assistance Program of FAO and the U.N., for the purpose of aiding governments in making forest inventories, in nursery and planting plans and operations, in managing their forest reserves, and in modernizing their wood-using industries to increase production and reduce waste. Above all, it meant seeking popular and legislative recognition and financial support by governments of their forestry staffs in the task of building up and conserving their resources particularly their forests, and making them serve the needs of the people in each country.

Following the completion of arrangements, involving visits to several countries, a number of interesting consultations, and considerable correspondence, the standardization meeting was held at Dalat, Vietnam, during April 3–7. Some eighteen delegates and observers from seven countries labored together and brought forth certain recommendations on standardizing names and terms, testing methods, grading, and dimensions of timber, and specifically, the training of log and lumber graders. As a result of these recommendations many of the governments sent in their contributions on trade and scientific names of timbers, on dimensions, and on grading specifications for compilation by the Secretariat. These Dalat recommendations were presented for consideration of the Inaugural Session (see below) of the Forestry and Forest Products Commission, and with slight modifications were accepted. As a result a working party on standardization was set up under the Chairmanship of M. Maurice Boucaud of the French Union. Towards the end of the year, M. Boucaud was in the process of obtaining from the various countries their nominations of technicians to serve on his Working Party.

The agreement of the countries of the Region in recognizing the importance of the principles of grading and of using the same terminology, sizes, and testing methods should go far in strengthening the hand of the foresters and the more progressive elements in the timber trade who are seeking to stimulate production and improve the marketing of forest products. As M. Boucaud's Working Party is able to work out the details of grades and dimensions for acceptance by future sessions of the Commission we can look forward to greater progress in putting both domestic and foreign markets for timber on a sounder basis than has been the case before now.

Undoubtedly the largest task of 1950 was the arrangement for the inaugural session of the Commission itself. Visits were made to most of the countries to discuss such details as time and place for the meeting, available facilities, personnel for the conference secretariat, items for the agenda, background and working papers, and participation by top-officials and forestry delegates and observers. During October, from the 9th to the 17th, some 33 representatives of 12 countries met at Bangkok, Thailand ; drew up the rules of procedure ; elected

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officers and Executive Committee ; reported to each other in detail on progress made by their governments on the Mysore recommendations ; considered the most urgent current problems ; and adopted resolutions instructing the Secretariat as to its future program. They recognized a statement of principles of forestry ; accepted the Dalat report (as mentioned above) as guiding principles, affirmed their interest in FAO's Expanded Technical Assistance Program, and urged that it be co-ordinated with related programs of governments and other international organizations ; restated the need for integration of forest industries ; expressed their desire to assist the U.N. in the supply of forest products in the rehabilitation of Korea ; and indicated interest in participating in a regional conference on soil conservation.

The statements, during the opening and subsequent meetings of the session, of the Prime Minister, H.E. Pibul Songkram, of our Honorary Chairman the Minister of Agriculture Pra Chuang Kasetr of Thailand, and of Dr. Egon Glesinger, Deputy Director of FAO's Division of Forestry and Forest Products, impressed the delegates with the importances which governments and international bodies attach to forestry and forest products in the economy of Asia, and the Pacific.

All of this was the result of the more formal phases of the conference. During the less formal phases, such as the field trips so effectively arranged by our hosts, the Thai foresters, and during the social get-togethers, the cordial relations between the foresters of all countries gave assurance of close future co-operation on an international basis for solving many problems which face the region. As one delegate put it "why can't political questions between countries be considered and resolved as harmoniously as our technical questions have been solved during our stay in Bangkok ? "

In line with invitations extended during these conferences, as well as in the course of visits to countries, the Secretariat was instrumental in arranging for Thai forestry students to take up their advanced studies at the Australian Forestry School at Canberra, at the School of Forestry of the University of the Philippines at Los Banos, and at the Forestry College at Dehra Dun, India. We had the privilege of endorsing the applications of foresters from Burma, Cambodia, and from Thailand for U.N. Fellowships for study and travel in U.K., U.S.A., Canada, India and Europe. We encouraged the foresters who came as delegates to the Dalat and Bangkok meetings to visit the foresters of as many countries as possible on their way to and from the sessions. Thai foresters stopped in Cambodia and Philippines ; men from SCAP visited Thailand ; Australia's and Ceylon's delegates inspected work in Malaya ; the Ceylon delegate visited Burma on his way home ; and Cambodian foresters came to Thailand on a visit. All who made such trips have written in subsequently to say how beneficial these exchanges of ideas have been to them, and to express the hope that more of this kind of thing will be done in the future.

Other efforts toward this exchange of information included the preparation of a regional bibliography, and the issuing of bi-monthly letters to chiefs of forestry services. The bibliography, covering material submitted by the governments for the period ending 31 December 1949, includes almost 3,000 references, arranged under the subject headings of the new Oxford Classification. Administrators and research workers should be able to see, from this bibliography, what has been done in the various fields of work in each of the other countries, and will thus know where to write to obtain reprints or additional information. At the same time it should serve as a first step towards co-ordinating research programs in the region.

The bi-monthly letters referred to above, serve to keep the heads of forestry services posted on developments and current activities of their colleagues in Asia and the Pacific. We have received a number of letters of encouragement and as we get more prompt and more complete reports of interesting items from the various country correspondents for UNASYLVA we can do a better job with these letters, as well as with the News Items section of UNASYLVA.

By the way, if you do not already receive our journal UNASYLVA, send in your subscriptions to Bangkok or to the local agent in your country. UNASYLVA will keep you up-to-date on forestry matters everywhere in the world, besides giving you authoritative information on technical aspects of forestry and forest products.

We have been co-operating with the Economic Commission for Asia and the Far East (ECAFE), particularly with its Bureau of Flood Control, and the Inland Transport Division. We have had the pleasure of working together with Dr. Shen-Yi and his staff in the Bureau of Flood Control in reviewing material for his Flood Control Journal, and in preparing working documents for the regional Flood Control meeting recently held in New Delhi. We are happy to report that he has a keen interest in proper land-use and resource conservation measures, particularly the use of vegetal cover, in all flood control programs.

In the case of Inland Transport Division, we have helped put together certain preliminary information on the use of wood as fuel by the Railways of Thailand, and to prepare a plan for a possible joint study on this subject for certain countries in the region who are concerned with this problem.

We have been in touch with the South Pacific Commission and with the Standing Forestry Committee of the Pacific Science Congress. The latter organization asked Mr. Florencio Tamesis, Chief of the Philippine Bureau of Forestry to serve as its observer (he already was his country's delegate) at our Bangkok session of the Commission. We have exchanged programs of work, received each other's comments, and kept each other informed, so as to dove-tail, instead of duplicate, our efforts in the Region. We appreciate the efforts of Mr. Stephen Wyckoff, Chairman of this Committee in encouraging his constituents to send into Bangkok their forestry references for our Regional Bibliography. We in turn are urging our Commission members to contribute as fully as possible to Mr. Wyckoff's project of surveying the status of forestry development in the countries associated with the Pacific Science Congress. The outline of reports which our members are making to FAO should be helpful in compiling the information sought by Mr. Wyckoff in time for his 1952 session of the Pacific Science Congress to be held in the Philippines, according to present plans.

Besides these general activities, which have been mentioned above, we have been trying to be of help on specific problems when requested to do so by individual countries. We have been able to obtain information regarding seed supply, methods of inventory, preservative treatment, availability of sleepers, charcoal, veneer logs, fuelwood and other products, on grading, and even on elephant logging. Much of this has been done through correspondence, but a considerable amount is done in the course of travel in the countries. Visits were made by a member of the Secretariat to Burma, Cambodia, Ceylon, India, Indonesia, Pakistan, and Vietnam during the year to consult with foresters and others on their various problems and to lay the groundwork for Technical Assistance Projects (more on this later).

In Burma we visited the Forestry School, which has been moved down from Pyinmana to Insein. The students were out on field tour, so we did not have an opportunity to visit with them. Not far away was the first of the Rehabilitation Brigade Camps which was just being set up by the young men assigned to it. Besides the work of building the camp, which involved the making of woven bamboo wall panels, putting in foundations of termite-resistant timber, making thatch roofing, and building furniture, the men received training in wood-working, foundry, and leather-tanning, U Maung Hman, Chief Conservator was working on plans to utilize these young men in nursery and plantation operations as well as in other activities connected with management of the nearby fuelwood and timber reserves.

In India after conferring at New Delhi with Inspector-General Chaturvedi and his Deputy J. Banerjee, with C. R. Ranganathan of the Dehra Dun Forest Research Institute and

Colleges, with officials of the Ministry of Industry and Supply, and of CWINC (the Central Waterways, Irrigation, and Navigation Commission) we made a short visit to West Bengal. At Calcutta, Conservator-General Chaudhuri discussed his program of trying to step up production in the mangrove forests along the coast, and in the hardwood forests in the northern part of his state. His Forest Utilization Officer, Mr. K. L. Lahiri, showed us the Government of India log depots which were receiving logs from current operations in the Andaman Islands, as well as a number of saw-mills and wood-using plants in and around the city. He conducted us to Siliguri where we saw forest plantations and forestry villages ; and to Darjeeling where Mr. Sen Gupta was playing host to the forestry students and their instructors from Dehra Dun. We had the pleasure of travelling with the students through the nurseries, plantations, villages, and erosion control works in the vicinity, even as far as the Nepal border. The very difficult task of trying to hold the soil on the extremely steep slopes to prevent critical land slips, which had destroyed parts of villages and sections of highway, was very impressive. The local forest officers had succeeded in enlisting the interest of private citizens to subscribe funds to augment the government funds for much of this work, an example, by the way, which might have application in other phases of forestry work, such as fire prevention and grazing control, not only elsewhere in India, but in other countries as well. The extensive plantations of *Cryptomeria japonica*, the Japanese Sugi, reminded us of the large scale reforestation activities we had seen in many parts of Japan in 1945 and 1946.

We were fortunate to get an awe-inspiring glimpse of magnificent Kanchenjunga when the mists and clouds separated just long enough to show the snow covered slopes so high above us. We failed to see Mt. Everest itself, but the unexpected view of Kanchenjunga amply made up for that. Others have described the scene many times before ; but to us, no word description can adequately express the inner feeling which one must experience personally to fully comprehend.

In Ceylon after official visits with Ministry officials we travelled with Dr. C. H. Holmes over various parts of the country. We saw the government log depots, private saw-mills, and furniture factories where beautiful carving of satinwood was being done. We visited the forest ranger schools just being built of Nissen Huts, one location in south central Ceylon and the other in the north central part of the island. We saw nurseries, plantations under shelterwood, natural regeneration in the wet evergreen type, and increment study plots in Hora (*Dipterocarpus zeylandicus*) stands. We watched the forest officers at timber checking stations along the highway examine loads of logs, an important activity of the Forest Department. We were particularly interested to see Honduras mahogany plantations regenerating naturally. There were very interesting experimental plots to secure natural regeneration in several forest types by controlled opening of the overhead canopy and by periodic cleaning operations.

Another vivid impression which deserves special mention is that the hottest curries ever encountered without exception, were here in Ceylon. At one Ranger's quarters, in particular, my eyes and nose ran so freely as I ate the delicious rice and curry, I could hardly see where to put my spoon after the fouth or fifth plateful.

In the northern, dryer, sandy parts of the island we saw slower-growing plantations of teak, mahogany, and broadcast-sown ebony. We were much interested in the trenching experiments to obtain natural regeneration in the dry evergreen forest type on sandy soil. We saw the results of poison girdling of the overwood near Anuradhapura. With Chief Conservator de Silva we visited teak plantations established by the *taungya* system in the region of chena (shifting agriculture) cultivation in north central Ceylon. Near Kurunegala we visited old plantations of mahogany under teak growing rapidly and of good form. We also saw plantations of jak (*Artocapus integra*) doing very well, and expressed the hope that with results like these the reforestation program might be continued on an expanded basis.

In the region around Nuwareliya we saw fuelwood cuttings in planted stands of eucalyptus, and mixed pines and cypress and other conifers in the slopes above the tea plantations. It was in this area where we saw the patnas, formerly forested but now covered by coarse grass, used to some extent for pasture. Extensive areas of this patna, where it is not needed for pasture might well be given over to forest plantations on an even bigger scale than has been the case heretofore. This could be justified by the success of past limited efforts in this direction, especially with *Acacia decurrens* which seems to improve the depleted soil for growth of better species. The Haputala Arboretum, with its many tall growing exotic trees, showed what growth can be expected in this part of Ceylon.

During a short visit to West Pakistan, Inspector-General S. A. Vahid took us to Rawalpindi, and Murree to see the forestry activities in Punjab, and to get acquainted with the staff of the Pakistan Forestry College, Ranger School, and the Forest Research Institute, set in forests of deodar, spruce, fir and *Pinus excelsa*. At Murree we visited the Survey of Pakistan to watch the making of maps for all branches of government, and what interested us most, for the Forest Department.

In the vicinity of Upper Topah we saw government timber depots where stocks of sleepers, naval stores gum, sections of pine logs for a match factory, and house timbers were being handled. We were much impressed with the efforts at gully control on the steep slopes, but especially by the success obtained in stabilizing such areas threatened with land slips merely by fencing out grazing animals and increasing the grass cover. As in West Bengal in India, this problem of controlling land slips was complicated, but essential to the maintenance of the mountain highways and villages.

We saw the Goragali vernacular school for forest guards from Punjab, North-west Frontier Province, and Azad Kashmir, the 21 trainees in khaki uniforms and red berets were keenly interested in their training; and showed justifiable pride in taking us around their school. The snap and enthusiasm of the men and their instructors would seem to offer good promise of a fine *esprit* in their forestry organizations after they return to their states.

In the plains between Murree and Rawalpindi we saw the spectacular reclamation of badly gullied land for cultivation, by the use of tractors and bulldozers. It was remarkable to see how a relatively small amount of moving soil to cut down the sides of steep gullies and build up terraces could convert idle waste-land into growing fields. As this work continues to be backed up more and more by control of the watersheds on the surrounding slopes, the permanence of this bulldozer-work will be assured, thus justifying the assignment of this task, to improve land use, to the Forest Department of the Punjab. The foresters are in the process of demonstrating the close interdependence of the farms on the plains and the forests and grazing areas on the slopes of the surrounding watersheds. Forest Conservator Riaz and his staff who conducted us over these areas understand this intimate tie-up very well.

We were also shown, before we left Punjab the newly established experiments in stimulation of gum flow on Chir pine (*Pinus longifolia*) by the use of acid.

In the North-west Frontier Province, Conservator Khan took us almost to the northern border of his area, and showed us fine stands of Chir pine, excellent regeneration, some effective erosion control work on steep slopes through closure to grazing and tree and shrub planting, on an extensive scale. The problem of modifying the past custom of uncontrolled cutting and burning in the village forests to more rational exploitation methods is receiving the special attention of the Conservator. Despite its complicated and delicate nature progress is being made in solving this problem. Patience and perseverance are required and Conservator Khan seems to possess an abundance of both of these qualities.

We were much impressed with the management plans and maps in the headquarters of the forest officers and the enthusiasm which these men showed in discussing the application of the plans. We had the feeling that if this area is typical of the whole country, Inspector-General Vahid is to be envied, and congratulated on heading up a fine organization.

In Cambodia, H. Chiem Reun, Cotrolleur des Eaux et Forets, conducted us on a two weeks tour of his country, particularly along the Mekong river in the vicinity of Stung Treng. We visited the pine forests (*Pinus merkusii*, *P. khasya*) at Kiri Rom to study the problems of opening up the area for logging and the possibilities of installing one or more saw-mills. We saw results of bad fires and their effects on natural regeneration in the open hardwood stands. The problem of shifting cultivation is serious, but progress is being made through forest villages whose inhabitants clear the low-grade forest ; make charcoal of much of the debris ; put the better material through small saw-mills to be made into locally needed housing lumber ; and plant teak seeds or seedlings among their crops on the cleared areas.

At the close of each of the trips described above, the various situations met with were discussed with the heads of the forestry services and with the appropriate Ministry officials. The object of these discussions was to determine whether Technical Assistance projects could provide possible solutions to the most immediate problems. As a result most of the countries in the region have asked for certain specific projects, and after further discussions with Dr. Glesinger of our Headquarters, agreements have been finalized, and FAO has been able to send in the requested experts. For example, Dr. von Monroy, an Austrian forester, was the first of such advisors to arrive in the region in FAO's Expanded Technical Assistance Program. He has had the task of advising the Burma Government as to the practical possibilities of establishing an *integrated forest industry*. Thailand has projects in (a) *survey of resources* (using aerial photographs as far as practicable) under J. Gonggryp of Netherlands ; (b) *reforestation* under Charles Letourneux of France ; (c) *management and working plans* under A. N. Barker of England, Ceylon has a project in *logging engineering* which is being handled by A. Decamps of France. Pakistan has projects in *minor forest products, particularly medicinal plants ; and logging engineering, saw-milling, and chemical utilization* in the Chittagong region, the experts for which are being recruited. India has requested several projects in connection with various lines of research activity at Dehra Dun, for which personnel has been selected and will report soon. Indonesia has requested a general forest policy and administrative advisor.

Besides the services of the experts in the country, most of the projects provide for training abroad of selected experienced individuals in the particular lines of work covered by specific projects. The purpose of such training fellowships is to assure the availability of trained technicians to carry out the experts' recommendations after these have been accepted by the respective governments. Such fellowships are of comparatively short duration and involve visits to operating units such as logging, saw-mills, plywood plants, other wood-using industries ; silvicultural and reforestation operations of government forestry services ; research projects at established forest experiment stations ; and in a few cases the trainees may take formal courses in such subjects as aerial photography, or even advanced work in forest management or utilization.

Additional projects are being formulated by these and other countries in the region ; more are welcomed.

In addition to these current activities, the groundwork was laid during 1950 for future work. The first is a training school for lumber graders. Preliminary plans are being formulated, financing is being investigated, and such details as time, place, instructors, subject matter, and teaching materials are to be worked out.

The second is the facilitating of the deliberations of the Standardization Working Party mentioned previously. We hope to supply the necessary documentation to the committee members, in the form of compilations of trade and scientific names, dimensions, grading rules and definitions, and descriptions of testing methods in use in the different countries. With this material it is hoped that the Working Party can come up with recommendations for the Commission to consider at its next session. This session, by the way, which is scheduled for 1952, will also require preliminary arranging during the coming year.

The compilation of statistics for commodity reports in UNASYLVA for the forest products yearbooks, and for the summary of annual reports of governments as recommended at the last Commission Session, will occupy an important part of the time of the Secretariat.

On April 1, 1951, the senior author of this paper is being transferred back to FAO Headquarters at Rome. Following his departure the co-author, Mr. Chandrasekhar Purkayastha, Regional Forestry Officer since April 1950, will be in charge of the Secretariat. He will have to assist him Mr. Mogens Andersen of Denmark as Regional Technical Assistance Officer.

The Executive Committee, of the Commission, consisting of Mom Chao Suebsukhswasti of Thailand as Chairman, Dr. C. H. Holmes of Ceylon as First Vice-Chairman, and Inspector-General Chaturvedi of India as Second Vice-Chairman will be working closely with your Secretariat at Bangkok.

This Secretariat is at your service. As we have said before, "Let us hear from you", through the head of your government forestry service.